

N91-15935

TOXIC AND REACTIVE MATERIAL HANDLING ON SPACELAB J AND USML-1  
By Jack Dashner

Spacelab J and USML-1 provide prime examples of materials which are toxic at ambient conditions or toxic during the processing stages. The materials are used in both life science and material processing experiments.

SPACELAB J

In addition to the experiments, the mission uses Mission Peculiar Equipment required to integrate the payload including a cooling water loop and a vacuum vent system. The vacuum vent plays an important role in toxicity control on Spacelab J.

While each of the experiments provide interesting and unique requirements for hazard control, the Frog Embryology Experiment (FEE), the General Purpose Work Station (GPWS), the FMPT Life Sciences (FMPT-LS) and FMPT Material Experiment Laboratory (FMPT-MEL) are the elements which contain most of the toxic materials.

The Frog Embryology Experiment is an Ames Research Center experiment developed in conjunction with the University of Michigan to study the effects of weightlessness in the development of amphibian eggs fertilized in space. Female African clawed frogs will be flown, ovulation will be induced and frog eggs will be placed in egg chambers. The eggs will be fertilized using testis and sperm prepared immediately before flight. Some chambers will be subjected to a one g centrifuge, Figure 1, to serve as a control group. Many of the chambers will be fixed with formaldehyde at predetermined periods following fertilization while others will be returned for continued ground studies.

This is a terse explanation of a very interesting experiment which will probably be discussed in a later session. From a toxicity standpoint, the fixative formaldehyde has a low maximum allowable concentration (MAC) and requires triple containment to meet the two failure tolerance required for hazards which could be catastrophic. Containment is provided by a syringe, sealed plastic bag, and a hard side sealed container during storage. Operations are performed inside of the General Purpose Work Station (GPWS), Figure 2. The GPWS provides a sealed container (closed environment) and provides the equivalent of a second containment by virtue of the filtering system which uses specially treated charcoal to remove formaldehyde and other toxic materials during the air circulation process. In the event of loss of power or other failures, the GPWS is placed in a closed loop operation which still provides one level of containment.

60021-184

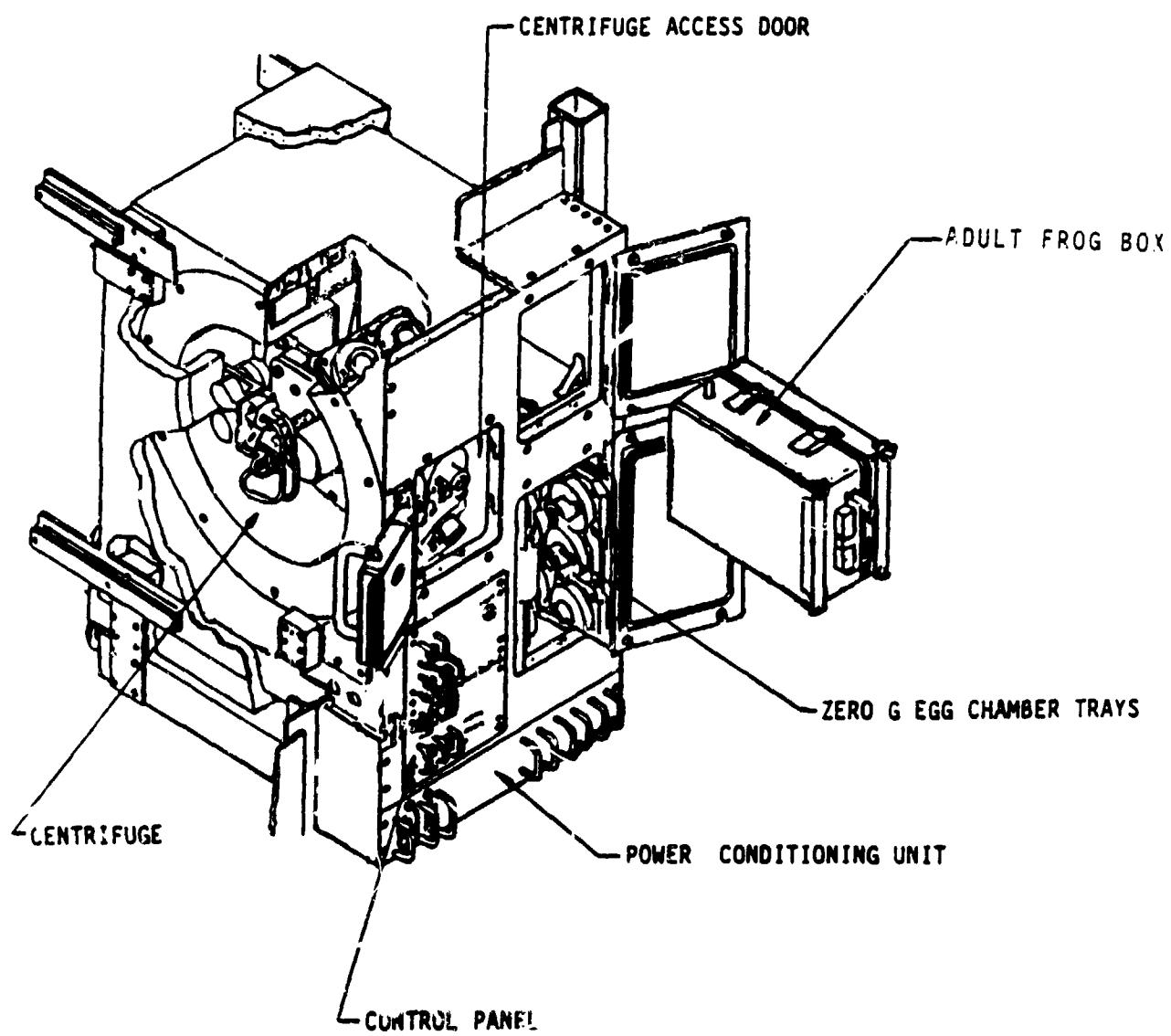


FIGURE 1. FSU EXPERIMENT CHAMBER

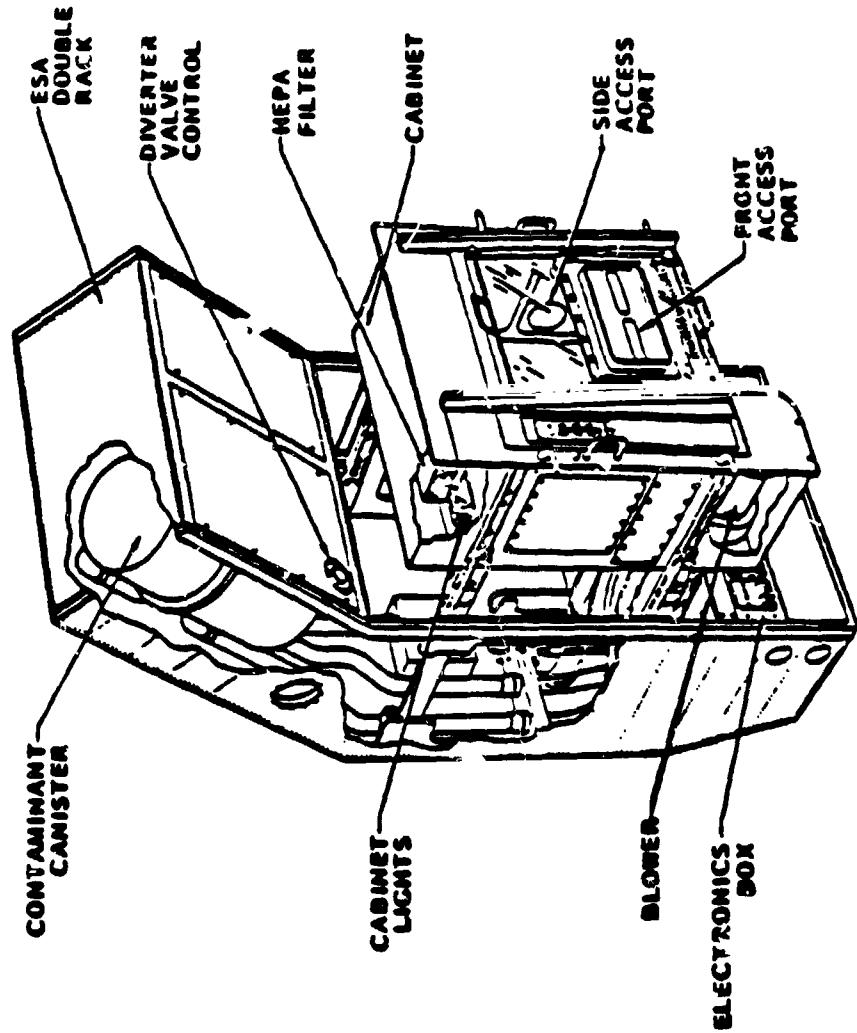


FIGURE 2 GPWS DESIGN OVERVIEW (IN DEPLOYED POSITION)

## EMPT Life Sciences

The Japanese experiments use hardware developed by both the Japanese and JSC to conduct 13 experiments including:

- Free Flow Electrophoresis Unit (FFEU)
- Vestibular Function Experiment Unit (VFEU)
- Thermo-Electric Incubator (TEI)
- Light Impulse Stimulator (LIS) Equipment
- Fungi Growth Chamber
- Enzyme Crystallization Kit
- Cell Culture Kit
- Fly Container
- Cosmic Radiation Devices
- Egg Rack
- Physiological Monitoring System
- Urine Monitoring System (UMS) - SL-3

The experiments contain numerous materials including biological materials, fish (2 carp), fungi, enzymes, animal and plant cells, fruit flies, seeds, hen eggs, and urine specimens. While each of the experiments has interesting and unique objectives, the fluids are low or non toxic and use single to dual containment. The cell culture kits present the greatest hazard principally due to the fixative agent glutaraldehyde which fixes samples at various stages of growth. This example has been selected principally to display a rather innovative syringe used to provide dual containment (Figure 3).

The life science experiments have been slighted in order to discuss the material processing facilities.

## EMPT - Materials Experiment Laboratory (MEL)

The FMPT-MEL will occupy two double Spacelab racks to house the experiments and support equipment. Figure 4 depicts the configuration and Table 1 identifies the equipment.

The FMPT-MEL consists of 22 experiments performed in 11 different facilities which include 6 different types of furnaces. The experiments and facilities are listed in Table 2.

In addition to the experiment facilities a dedicated vacuum facility is required in conjunction with a turbomolecular pump to provide a high quality vacuum. Additionally, high pressure gases (3000 psi helium, 3000 psi synthetic air, 3000 psi argon, and 1000 psi krypton) are provided for processing, quenching, purging and pneumatic valve operation.

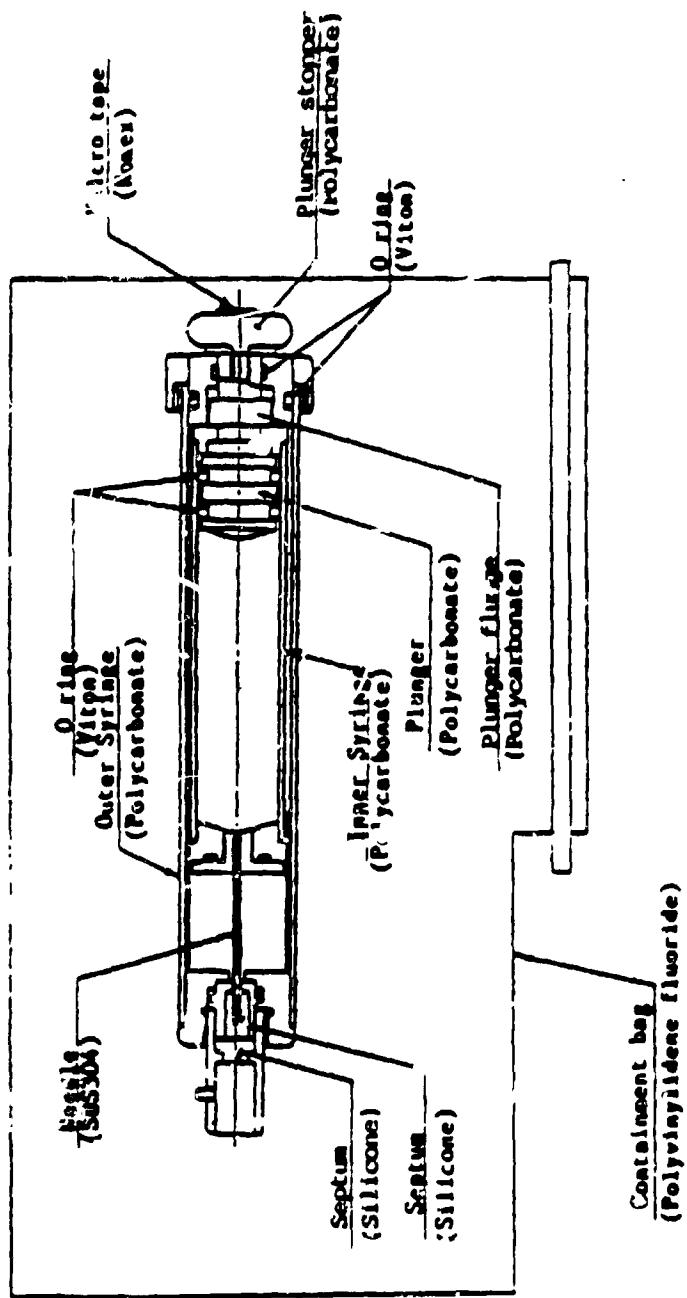
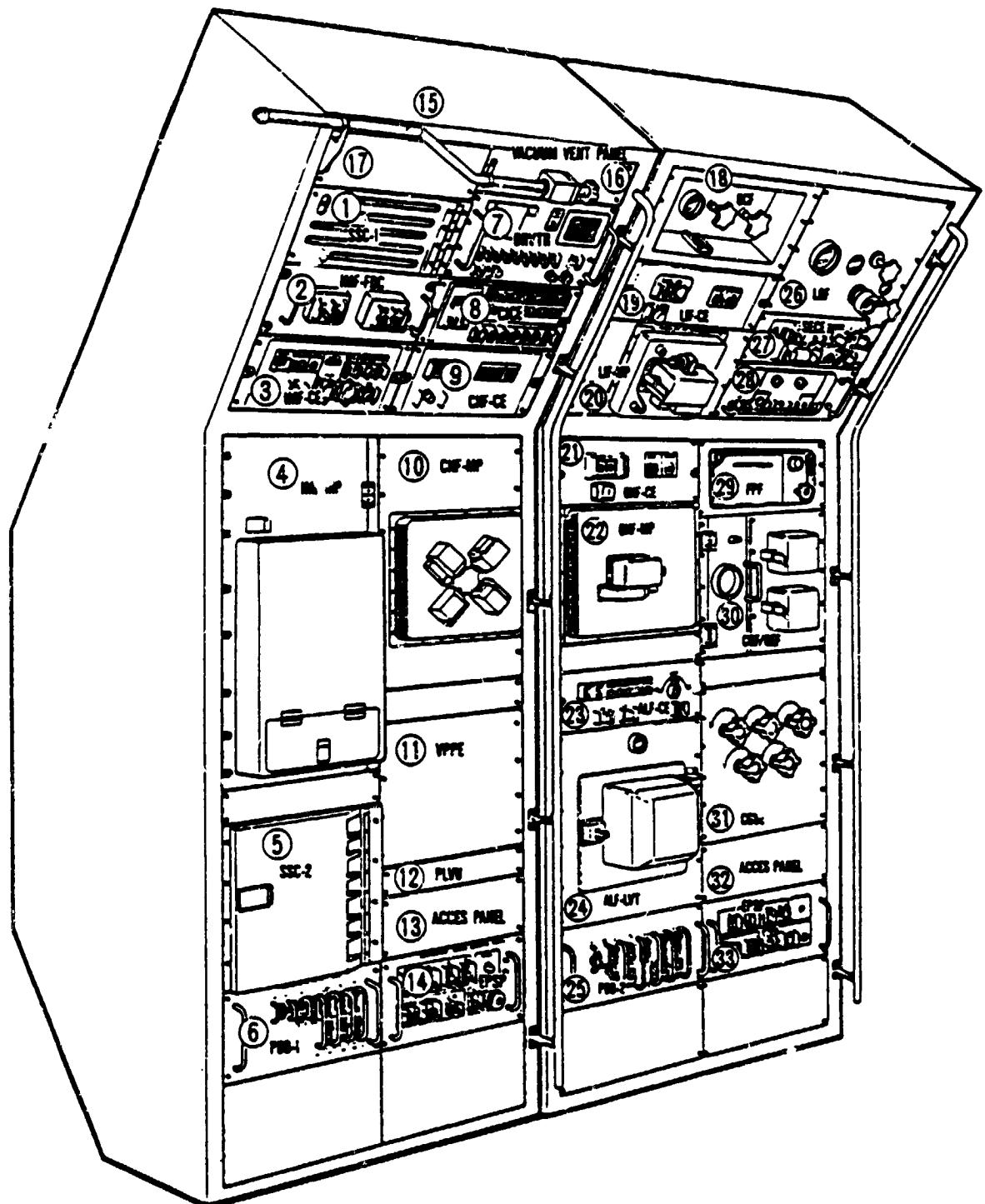


FIGURE 2 Glutaraldehyde Container (Nozzle Syringe Type)

ORIGINAL PAGE IS  
OF POOR QUALITY



NOTE: The equipment numbers on this page correspond to the numbers and titles in Table 8-1.

FIGURE 4 FMPT-MEL EXPERIMENT

TABLE 1. FMPT-MEL EXPERIMENT EQUIPMENT  
IN SPACELAB RACKS 8 AND 10

- 1 Sample Stowage Container (SSC-1)
- 2 Image Furnace - Furnace Drive Controller (IMF-FDC)
- 3 Image Furnace - Control Equipment (IMF-CE)
- 4 Image Furnace - Material Processing Unit (IMF-MP)
- 5 Sample Stowage Container (SSC-2)
- 6 Power Distribution Box-1 (PDB-1)
- 7 Data Recording Video Tape Recorder (DRVYR)
- 8 Central Interface and Control Equipment (CICE)
- 9 Continuous Heating Furnace - Control Equipment (CHF-CE)
- 10 Continuous Heating Furnace - Material Processing Unit (CHF-MP)
- 11 Vacuum Pump Package Equipment (VPPE)
- 12 Pilot Valve Unit (PLVU)
- 13 Access Panel
- 14 Experiment Power Switching Panel (Rack 8)
- 15 Vent Line
- 16 Vacuum Vent Panel
- 17 Blank Panel
- 18 Organic Crystal Growth Experiment Facility (OCF)
- 19 Large Isothermal Furnace - Control Equipment (LIF-CE)
- 20 Large Isothermal Furnace - Material Processing Unit (LIF-MP)
- 21 Gradient Heating Furnace - Control Equipment (GHF-CE)
- 22 Gradient Heating Furnace - Material Processing Unit (GHF-MP)
- 23 Acoustic Levitation Furnace - Control Equipment (ALF-CE)
- 24 Acoustic Levitation Furnace - Material Processing Unit (ALF-LVT)
- 25 Power Distribution Box-2 (PDB-2)
- 26 Liquid Drop Experiment Facility (LDF)
- 27 Specific Experiment Control Equipment (SECE)
- 28 Intercom Remote Station (ICRS)
- 29 Fluid Physics Experiment Facility (FPF)
- 30 Crystal Growth Experiment Facility and Gas Evaporation  
Experiment Facility (CGF/GEF)
- 31 Compressed Gas Supply Equipment (CGSE)
- 32 Access Panel
- 33 Experiment Power Switching Panel (Rack 10)

TABLE 2. EXPERIMENT PLANNED FOR FMPT-MEL MISSION

Exp	Title	Facility	Remarks
M1	Crystallization of Pb-Sn-Te	GHF	Compound type semiconductor single crystal growth
M2	Zone Melting of Pb-Sn-Te	IMF	Compound type semiconductor single crystal growth
M3	Floating Zone of In-Sb	IMF	Compound type semiconductor single crystal growth
M4	Solidification of Superconducting Materials	CHF	Solidification process of immiscible alloys (Al-Pb-Bi)
M5	Deoxidation of Steels	LIF	Removal of solved oxygen from molten steel
M6	Dispersion - Strengthened Superalloys	LIF	Superalloy matrix reinforced by dispersed fine particles
M7	Mutual Diffusion in Liquid Metals	CHF	Study of diffusion process
M8	Density of Glasses	IMF	Measurement of glass density as function of temperature
M9	Spherical Si Crystals	CGF	Production of spherical Si crystals
M10	Solidification of Immiscible Alloys	GHF	Solidification process of immiscible alloys (Al-In, Cu-Pb)
M11	Composites (Al-Carbon Fibers)	CHF	Al Matrix with 3-dimensional carbon fiber reinforcement
M12	Liquid Phase Sintering	LIF	Production of metal powder by liquid phase sintering
M13	Amorphous Semiconductors	CHF	Production of amorphous semiconductors
M14	Ultra-Fine Powders	GEF	Metallic powders produced by evaporation process
M15	Fluid Dynamics in 3-D Acoustic Field	LDF	Behaviour of liquid drop levitated in acoustic field
M16	Behaviour of Bubbles in Liquid	BU	Bubble behaviour at liquid-to-crystal interface
M17	Firing of Glasses	ALF	Contactless meeting of very pure glasses
M18	Marangoni Convection and Heat Transfer	MCU	Effects of Marangoni convection on Brigheman process
M19	Solidification of Eutectic Alloys	CHF	Study of solidification process
M20	Floating Zone of Minerals	IMF	Growth of single crystals from Samarskite minerals
M21	Organic-Metallic Crystals	OCF	Growth of crystals from organo-metallic compounds
M22	Crystallization of In-Ga-As	GHF	Compound type semiconductor single crystal growth

Furnace operations generally require installation of experiment samples by hand and automatic processing by computer although manual controls are available for hazardous function control. For all furnaces interlocks and doors are provided to prevent sample removal prior to cooling to touch temperatures of 45°C.

#### Gradient Heating Furnace (GHF)

The GHF, Figure 5, has been developed for several types of experiments such as crystal growth, melting/solidification, and eutectics. The facility functions by positioning the sample, and after heatup, the furnace translates to provide a moving gradient across the sample. The furnace uses two heating coils at one end and a single coil at the other end. Between the coils is a water cooling chamber. The furnace, which operates at temperatures up to 1100°C, processes the sample in a vacuum. Two samples, M 01 and M 22 of Table 3 provide three levels of containment by the use of two quartz ampoules and a tantalum cartridge. Sample M 10, Figure 6, is encased in an unsealed tantalum cartridge. The metals in this sample will offgas toxic gases during processing. Containment is provided by the furnace (one level) and by use of the vacuum vent line. During processing, the toxic residue is pulled in to the vent line for release to space. Based on partial pressures, the offgas rates are low. In order to use the concept that vacuum venting provides the equivalent of containment there are safeguards required. The furnace pressure is continuously monitored and must remain negative in relation to Spacelab ambient pressure. In the event that the furnace pressure approaches module pressure, the furnace automatically shuts down. The sample materials are nontoxic in the solid state and sample M 10 remains in the furnace after processing.

#### Imaging Furnace (IMF)

The Imaging Furnace, Figure 7 and 8, is designed to accommodate several samples, including crystal growth, by pulling the crystallization zone along the sample axis. The IMF contains twin ellipsoidal mirrors with one common focus where the sample is located. Two halogen lamps, each located at the focal point of the ellipsoid, provides the heat source. Movement of the melting zone is accomplished by moving the twin mirror furnace along the sample axis. A quartz tube is installed over the samples during processing and an inert gas, argon, flows past the sample. All pressure inside of the furnace, including the argon is at a negative pressure in relation to the module. The pressure is continuously monitored and the furnace automatically shuts down for positive pressure. As in the GHF, the vacuum vent serves as a containment level equivalent. The IMF will process four types of samples. Samples M 02 and M 08 of Table 4 use a quartz ampoule for processing. Figure 9 shows one of the quartz ampoules. Samples M 20 and M 03 (Figure 10) both are naked samples. The naked samples use the sealed IMF and vacuum vent to achieve containment. The IMF is equipped with two view ports to allow visual inspection of the samples to assure that toxic ash or residue has not coated the interior of the furnace. Handling of processed samples requires the use of disposable gloves and samples are placed in sealable bags for storage.

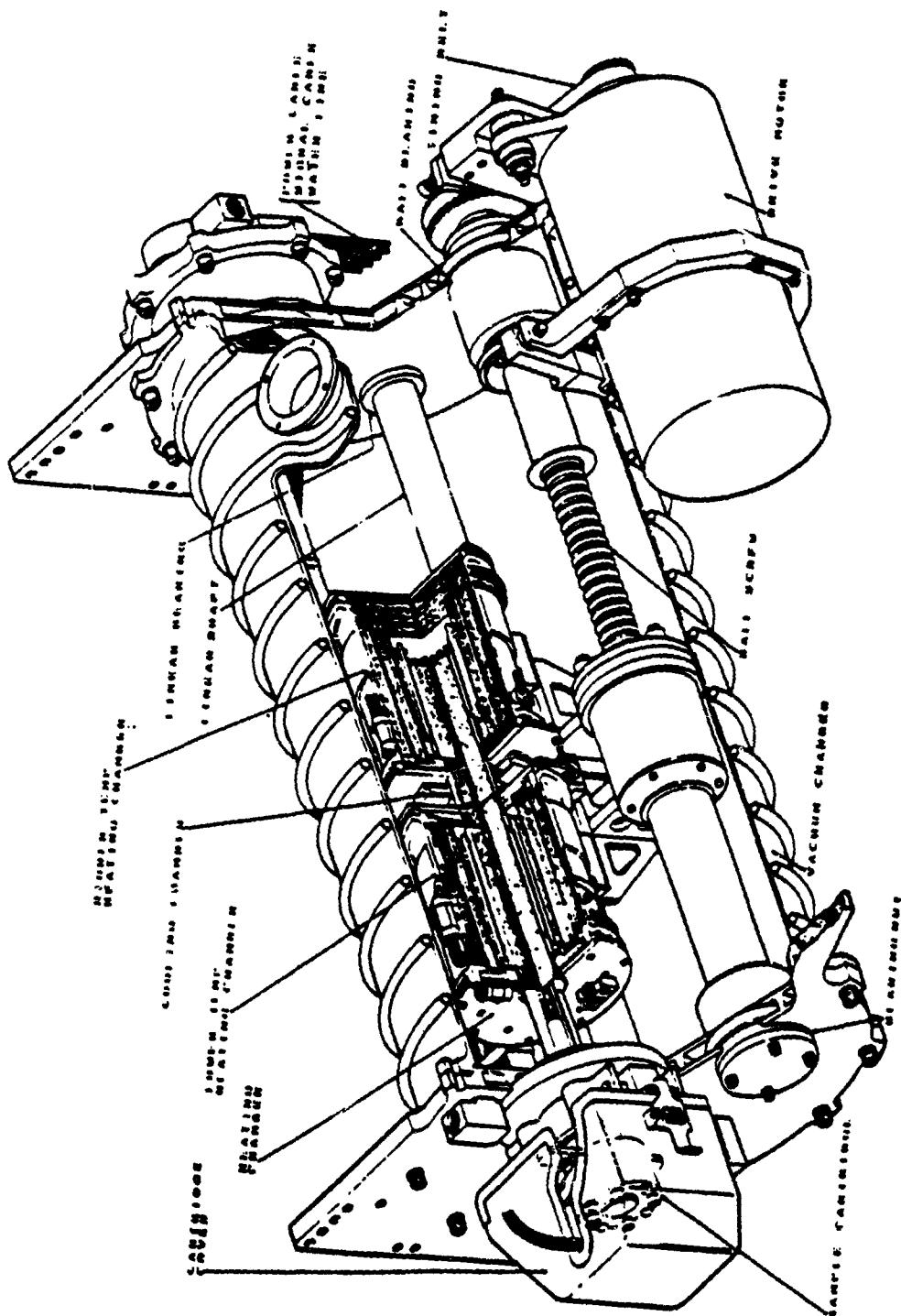


FIGURE 5 GHF-MP FURNACE

ORIGINAL PAGE IS  
OF POOR QUALITY

Table 3 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
M 01	Pb		1 0 0 0	0 . 0 4	3 Containments 2 qtz & Ta
	Sn			0 . 0 4	
	GHF			0 . 0 2	
	Te	9 1			
M 22	In		1 0 7 0	0 . 0 2	3 Containments 2 qtz Amp
	Ca			0 . 5	Ta Cart
	As			0 . 0 0 2	
	GHF				
		1 8			
M 10	Al		1 0 5 0	2	Unsealed Ta Cart
	In			0 . 0 2	Remains In
	Cu			0 . 0 4	Furnace
	Pb			0 . 0 4	
		2 6 . 5			

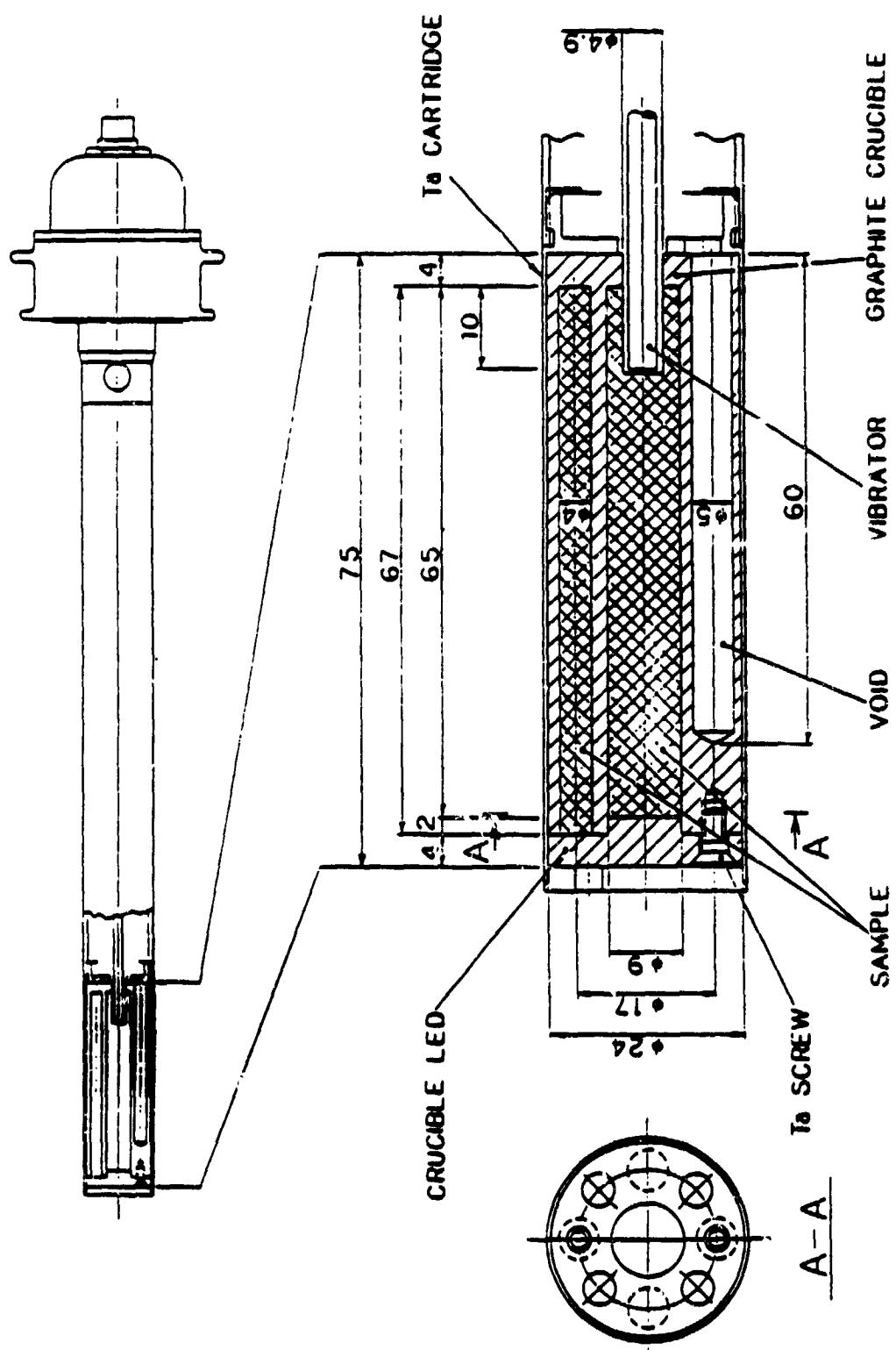


FIGURE 6 FO'NIO SAMPLE

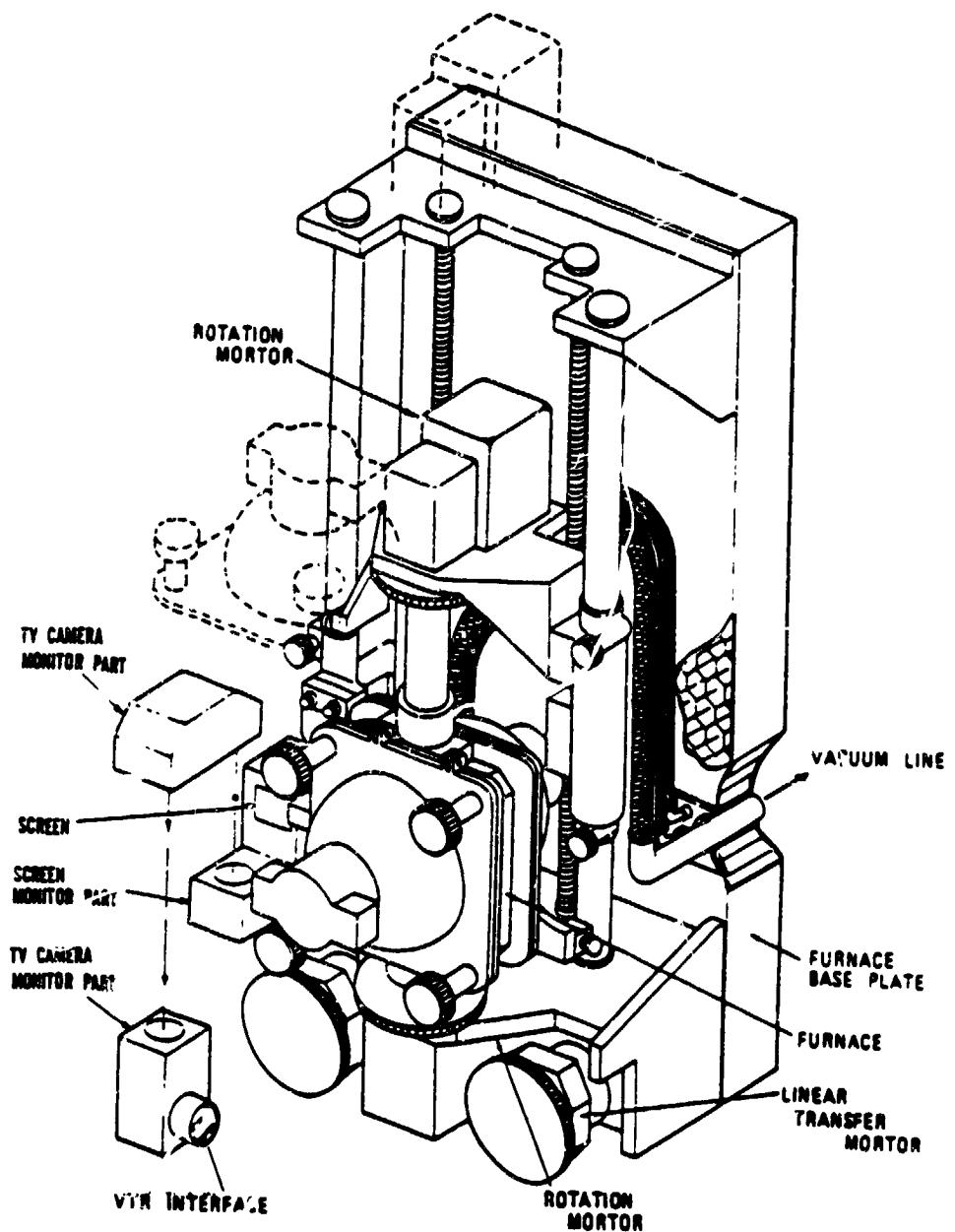


FIGURE 7 IMF-MP FURNACE

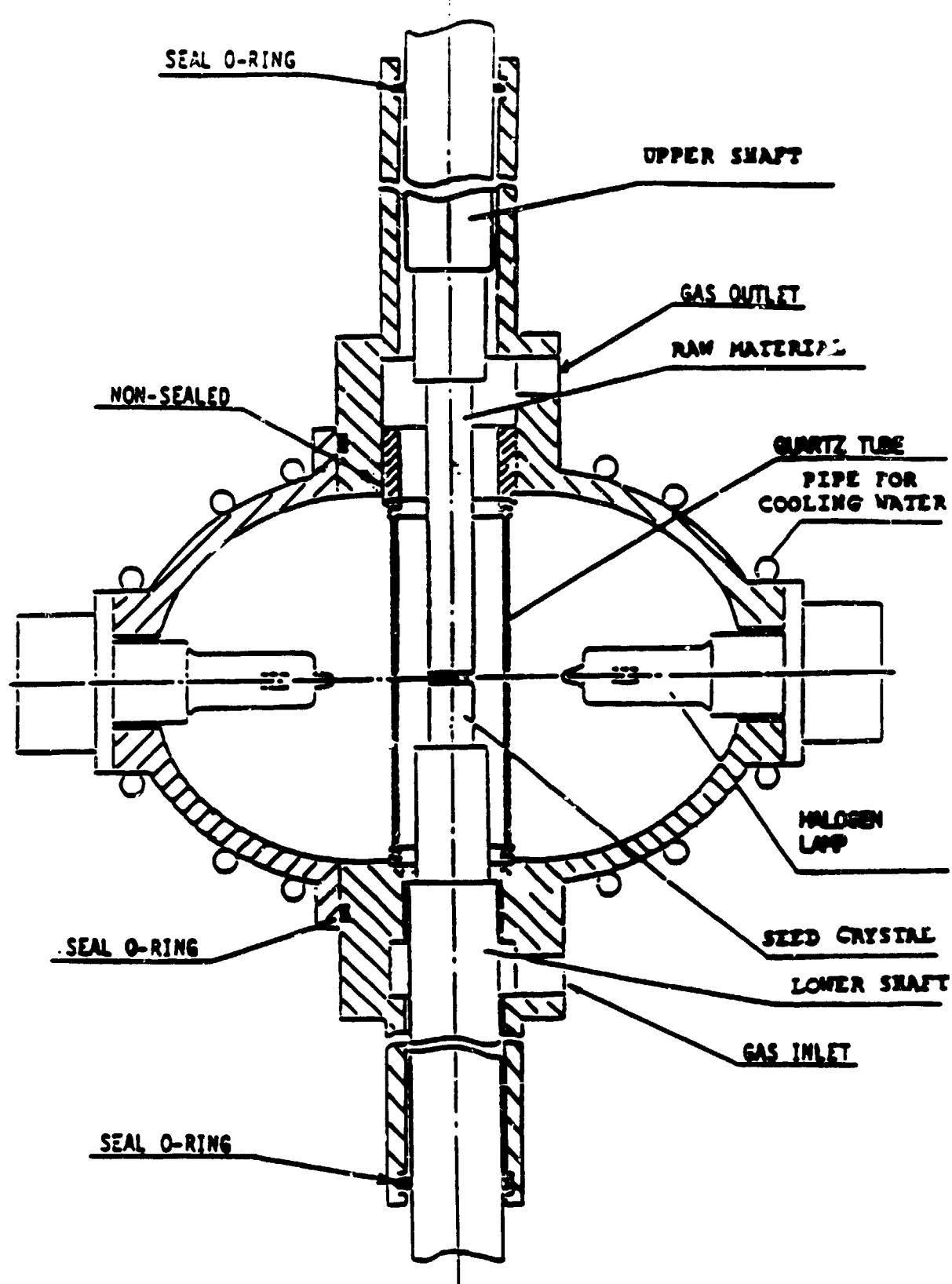


FIGURE 8 INSIDE OF IMP FURNACE

Table 4 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature $^{\circ}\text{C}$	SMAC $(\text{mg/m}^3)$	Containment
M 0 2	Pb		850	0.04	1 QUARTZ
IMF	Sn			0.04	
	Te			0.02	
M 0 8	$\text{Na}_2\text{O}$	1200	0.4	1 QTZ AMP	
	$\text{B}_2\text{O}_3$		2.0		
IMF	$\text{CaO}$		0.4		
	$\text{CoO}$		0.0254		
	Au		1.0		
				1.162	

Table 4 (cont'd) FIAPT-MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity	Process Temperature °C	SMAC <sub>3</sub> (mg/m <sup>3</sup> )	Containment
<b>M 20</b> IMF	CaO UO <sub>2</sub> YO <sub>1.5</sub> FeO NbO <sub>2.5</sub>		1400 ?	0.4 0.25 1.0 (Fe <sub>2</sub> O <sub>3</sub> ) 0.5	Naked
<b>M 03</b> IMF	In Sb		1.33 374.1 (Max.)	550 0.02 0.1	Naked-Furnace 1-Remains In Furnace

\*\*Does Not Exceed SMAC

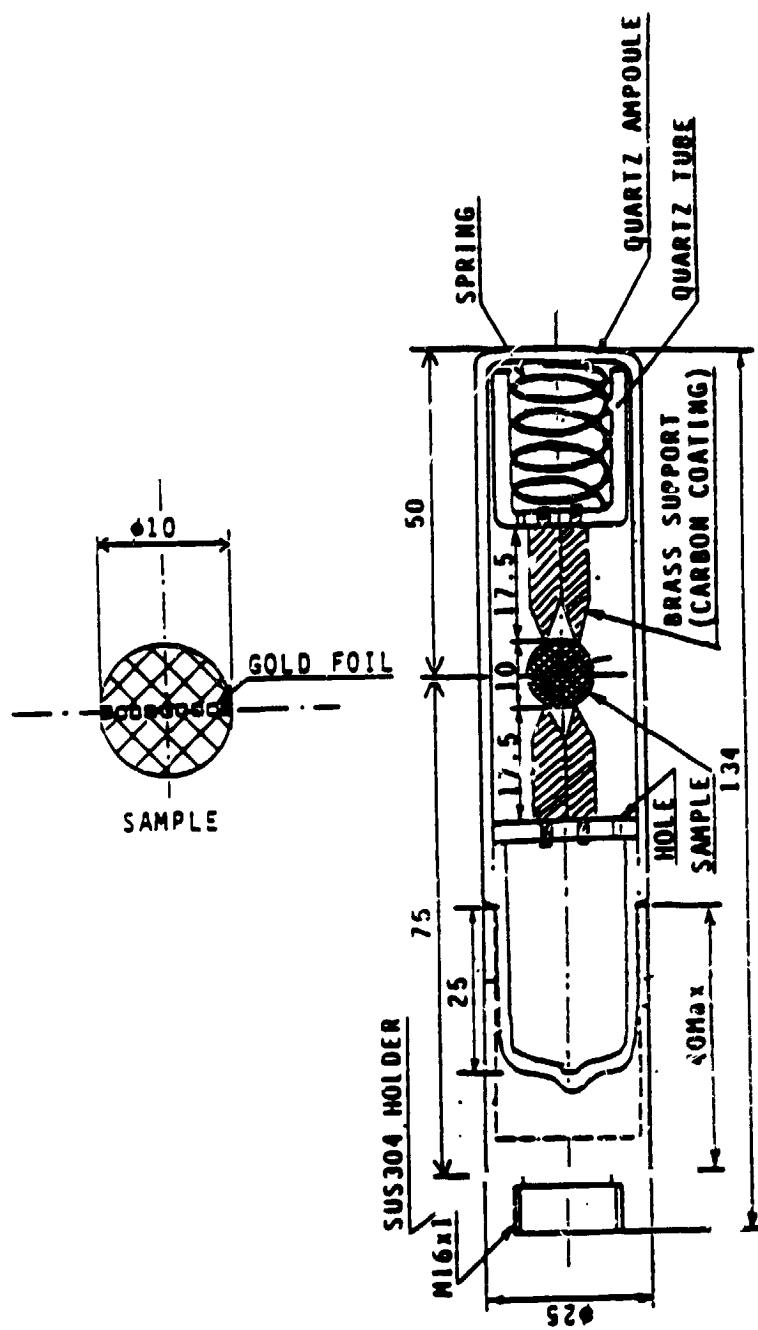


FIGURE 9 FO-408 SAMPLE

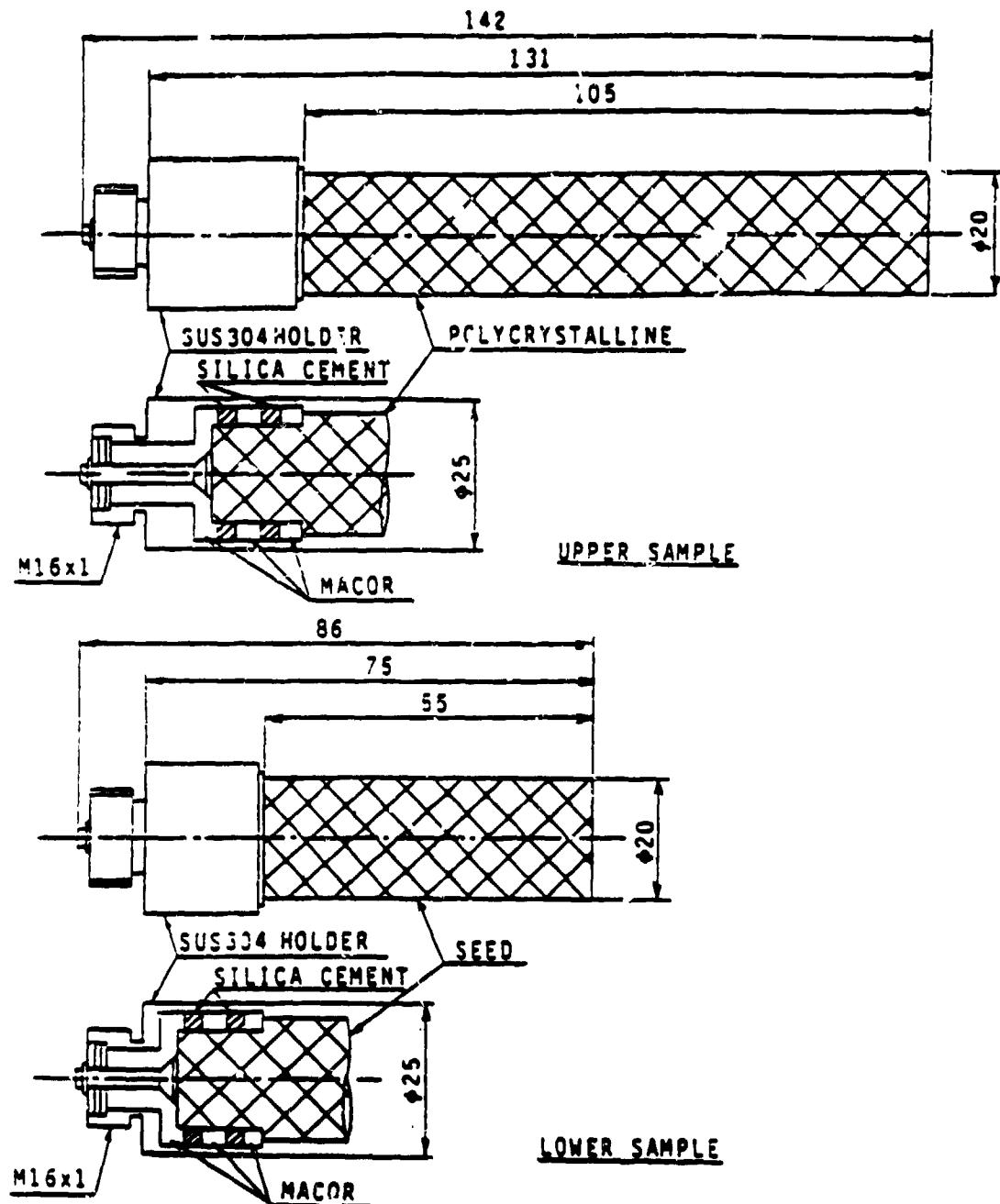


FIGURE 10 FO MO3 SAMPLE

### Continuous Heating Furnace (CHF)

The CHF, Figure 11, is a unique vacuum furnace designed to process samples continuously. The CHF combines two heating chambers and two water cooled chambers to achieve continuous heating of two samples and rapid cooling of two samples. The furnace operates at a maximum of 1300°C and can cool two samples from 1200°C to room temperature in approximately 10 minutes. Heating and cooling chambers are alternately arranged. The furnace translates fore and aft to position the chambers over the samples. After heat up and sample processing, the furnace translates aft, rotates 90°, and then translates forward such that samples which were being heated, are then cooled. At the completion of the cooling cycle (touch temperature of 45°C) the cooled samples are replaced with new samples for the next phase. The CHF will process five sample types - M 04, (Figure 12) M 07, M 13, M 19, and M 11 of Table 5. All of the samples provide triple containment except M 11, Figure 13, which provides dual containment. In this case the furnace and vacuum provide the extra levels of containment. All of the containments are somewhat different, however the examples, Figures 12 and 13 are representative.

### Large Isothermal Furnace (LIF)

The LIF, Figure 14, is a vacuum heating furnace which operates at temperatures up to 1600°C. Provisions are made to allow pressurization of some sample cartridges at 6 bar (Figure 15). Furnace heat up and processing are accomplished in a vacuum and cooling uses helium gas at pressures which are negative in relation to the module. In the event of positive pressure, the furnace automatically shuts down. Three sample types will be processed - M 05, M 12, and M 06 of Table 6. Both M 05 and M 12 cartridges provide dual containment while M 06 is a naked sample which remains in the furnace after processing. Figure 16 depicts one of the sample cartridges while Figure 17 shows the naked sample.

### Crystal Growth Facility (CGF)

The CGF, Figures 18 and 19, consists of two furnace chambers, one for a spherical sample and one for a bar sample. The furnaces operate at temperatures in excess of 1400°C and samples are processed in gaseous argon which is at a negative pressure in relation to the spacelab module. In the event the furnace pressure approaches module pressure, the furnaces automatically shut down. Each furnace chamber will process one naked sample of silicon (Sample M 09 of Table 7) which will remain in the furnace after processing until removal on the ground. Silicon is a low toxic material and the furnace plus the vacuum vent provide adequate containment.

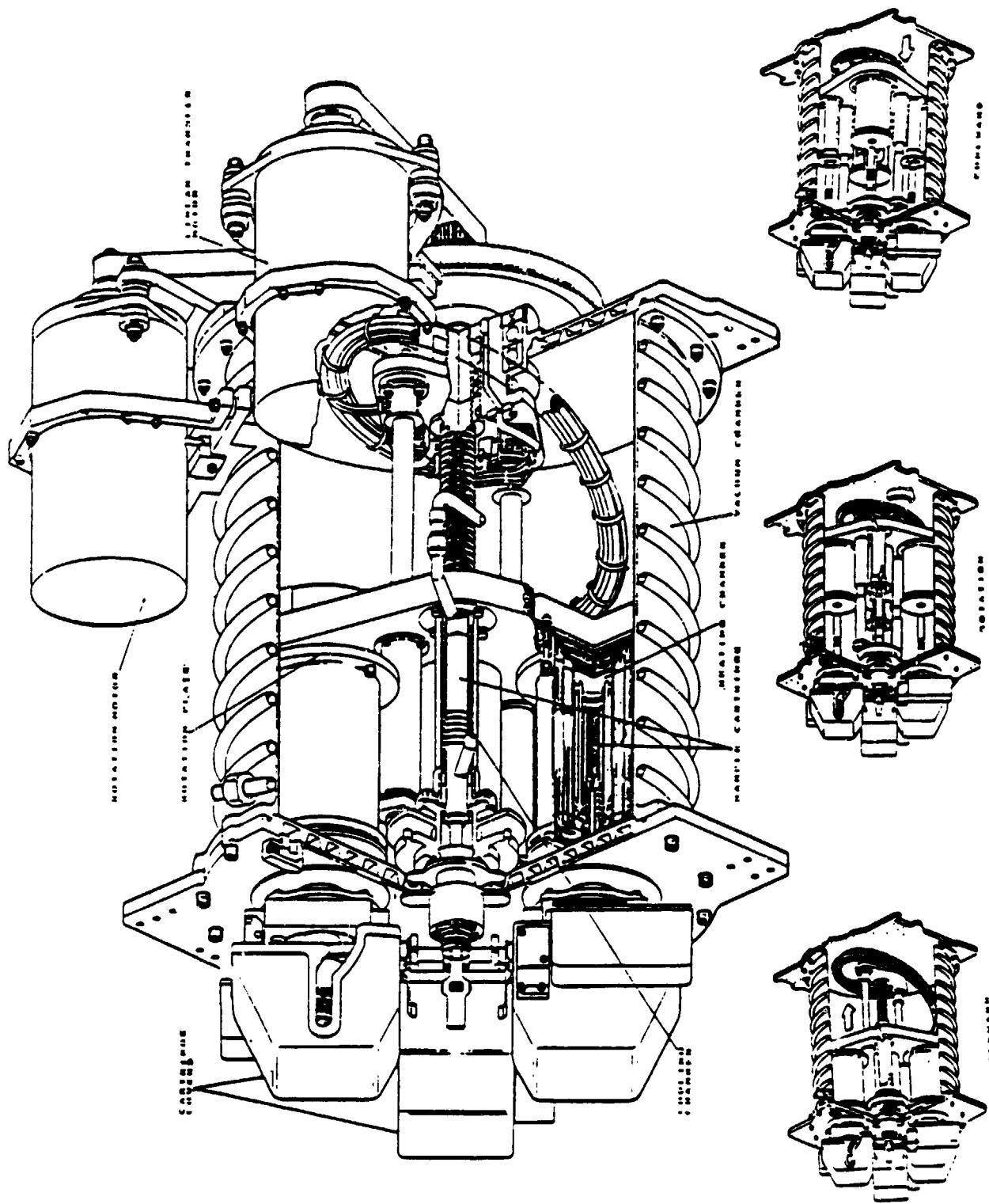


FIGURE 11  
CIF-MP FURNACE

ORIGINAL PAGE IS  
OF POOR QUALITY

Table 5 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
M04	AI	a. b. c.	1300	0.04	2 3 Containments 2 Ta Cap 1 Ta Cart
CHF	Pb	a. b. c.	1300	0.5	
BI		a. b. c.	1300		
	(total)	a. b. c.	6.69 6.69 6.69		

Table 5 (cont'd) FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mΩ/m <sup>3</sup> )	Containment
<b>M 07</b>	<b>Au</b>		1300	1 0.02	<b>3 Containments</b> 2 QTZ AMP 1 TA CART
<b>CHF</b>	<b>Ag</b>	<u>6.9</u>			
<b>M 13</b>	<b>Si</b> <b>As</b> <b>Te</b> <b>Mn</b>		1300	<b>2</b> 0.002 0.02 0.2	<b>3 Containments</b> 2 QTZ AMP TA CART
	<b>CHF</b>			<u>6</u> <i>In total</i>	

Experiment/Equipment		Quantity	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
<b>M-13</b>					<b>3 Containments</b> 2 QTZ AMP 1 Ta CART
CHF			2	0.002	
		Si	1300		
		As	1300		
		Te	0.02		
		Mn	1300		
			0.2		
					(total)
					a. 1.00000
					b. 1.00000
					c. 1.00000
					d. 1.00000
					e. 1.00000
					f. 1.00000

Table 5 (cont'd) FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature $^{\circ}\text{C}$	SMAC <sub>3</sub> (mg/m <sup>3</sup> )	Containment
M 19 CHF	Al	2 ea. X	-	-	3 Containments 2 QTZ AMP Ta CART
	Cu		700	2	
	(total)	a. 1.40 b. 1.40 c. 1.40		0.04	
M 11 CHF	Al In C	6 ea. X		2 1550 4.51	2 Containments QTZ AMP Ta CART

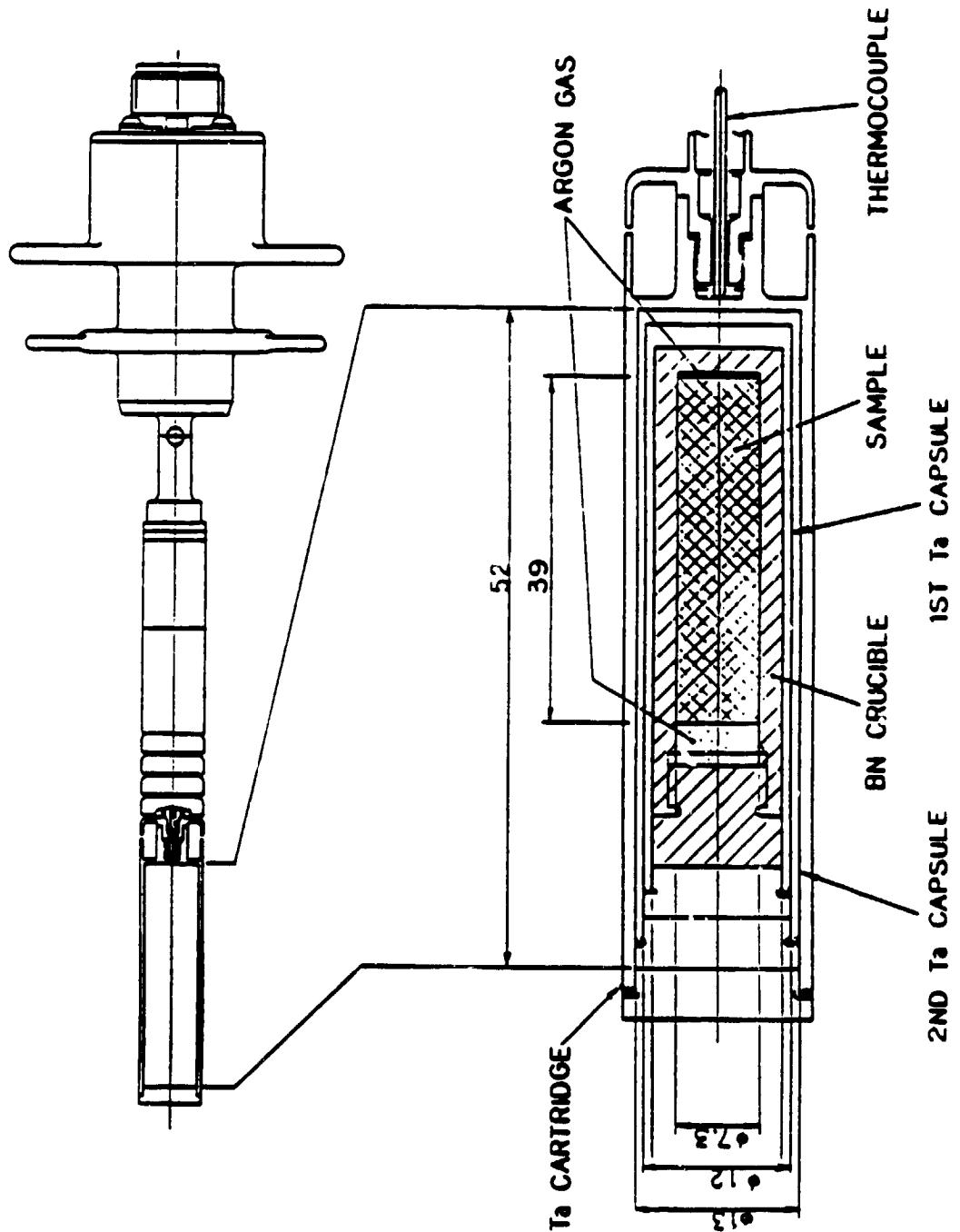


FIGURE 12 F0 MO4 SAMPLE

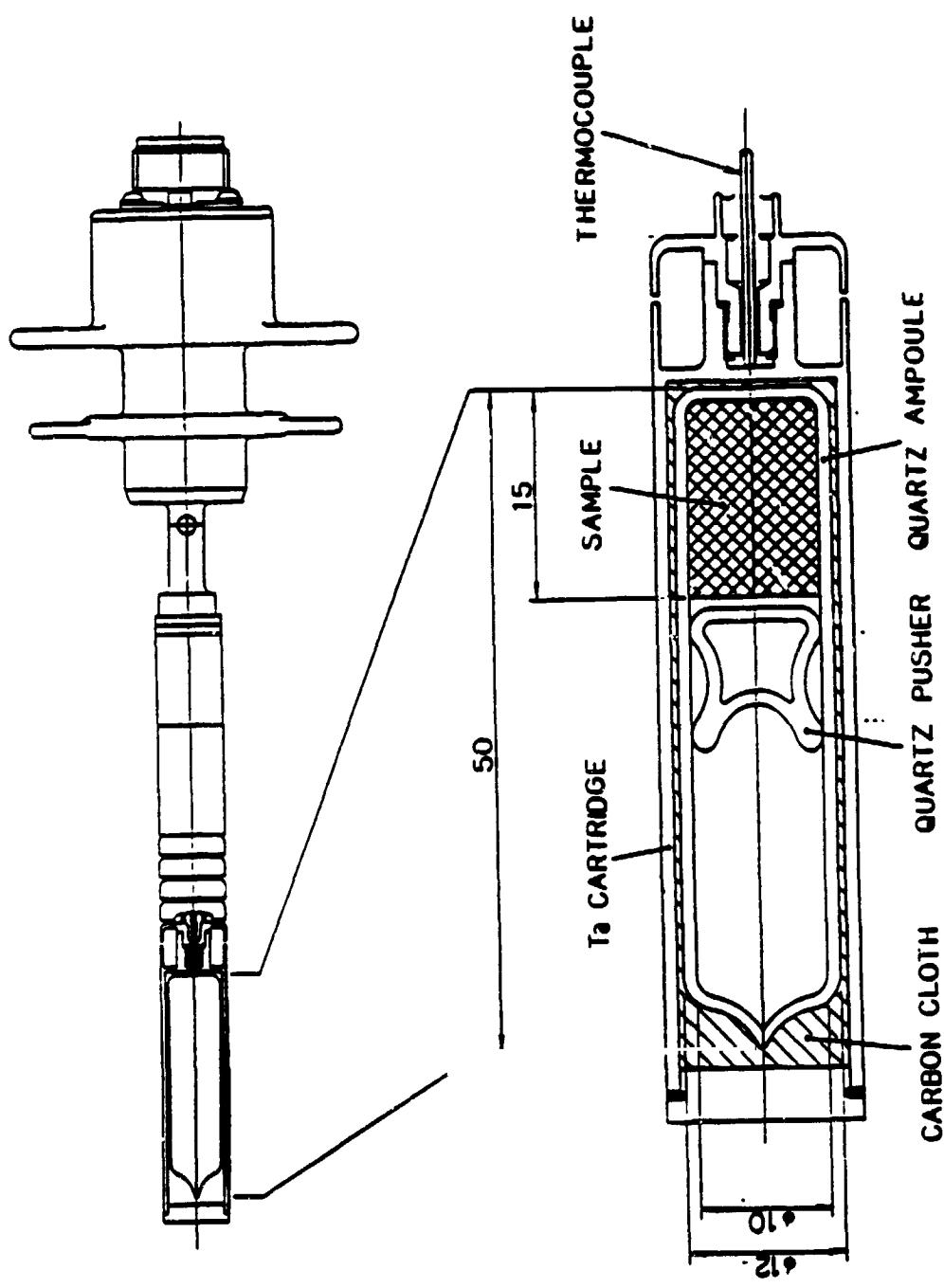


FIGURE 13 TA 111 SAMPLE

Table 6 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
M05 LIF	Fe Ni Al Mn Si O		1600	1 0.08 2.0 0.2 2 -	2 Containments MOLY CONT. Ta CART
			<u>57.6</u>		
M12 LIF	W Ni		1550	1 0.08	2 Containments Ta CAPSULE Ta CART
			<u>43</u>		
M06 LIF	Ni Mo Cr Co TiC		1380	0.08 3 0.1 0.009 3	Unsealed: Left In Furnace
			<u>168.68</u>		

Table 6 (cont'd) FMPT - MEL SAMPLE DATA

Experiment/ Equipment	Ingredients	Quantity	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
<b>M 06 (CONTINUED)</b>	(Glass Sealant) SiO <sub>2</sub> B <sub>2</sub> O <sub>3</sub> Na <sub>2</sub> O Al <sub>2</sub> O <sub>3</sub> K <sub>2</sub> O Fe <sub>2</sub> O <sub>3</sub> LiF			?	

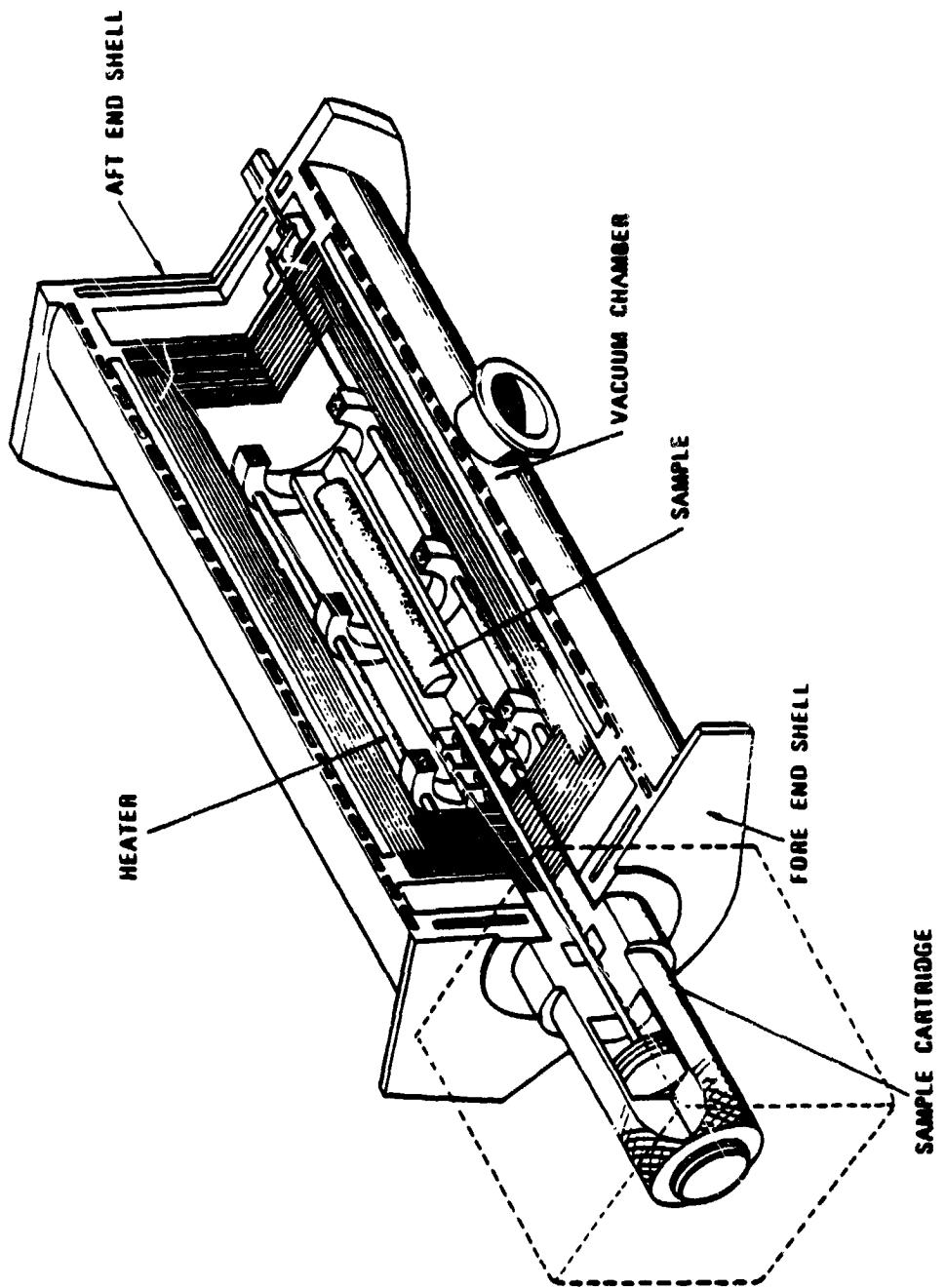


FIGURE 14 LIF-MP FURNACE

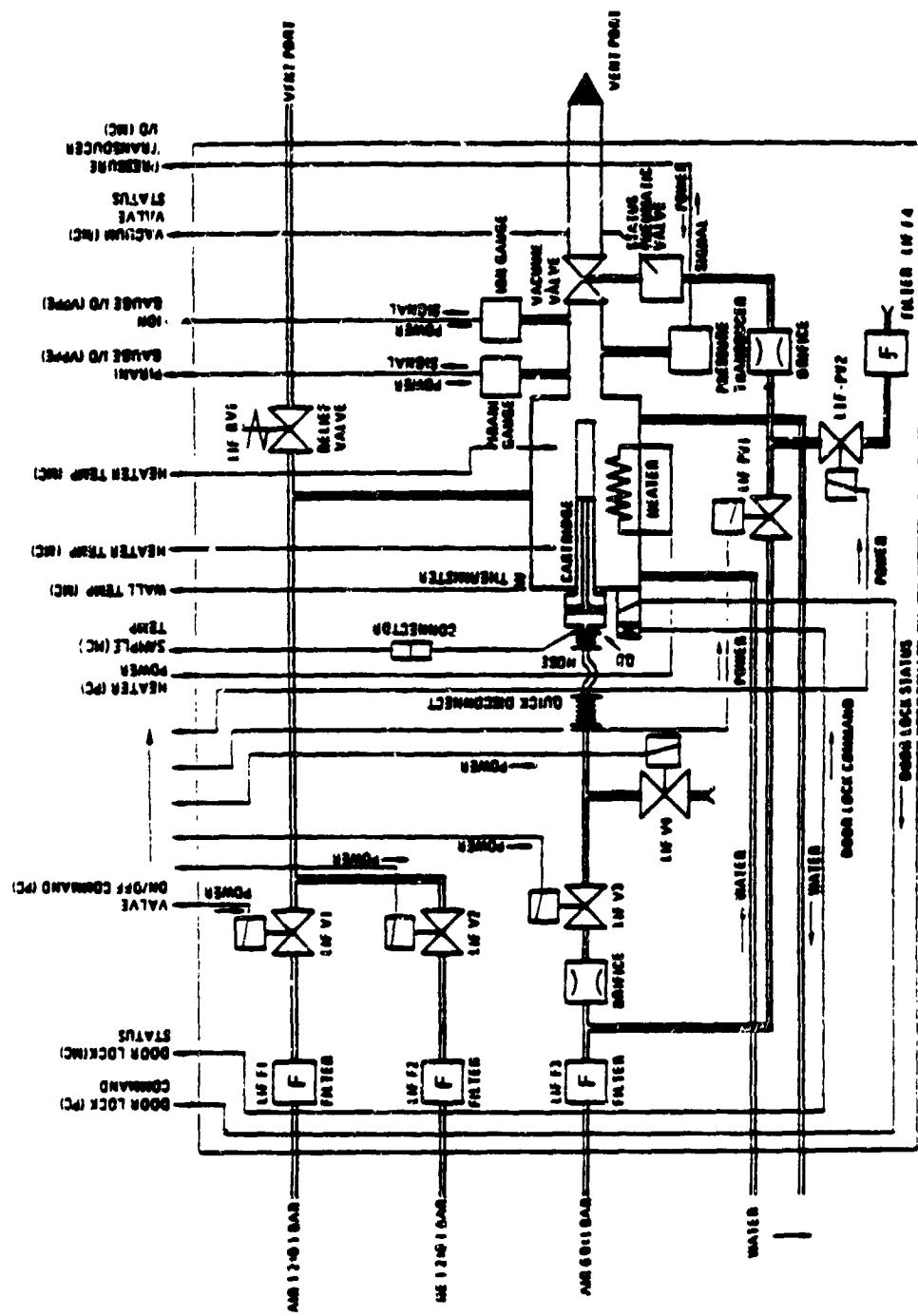
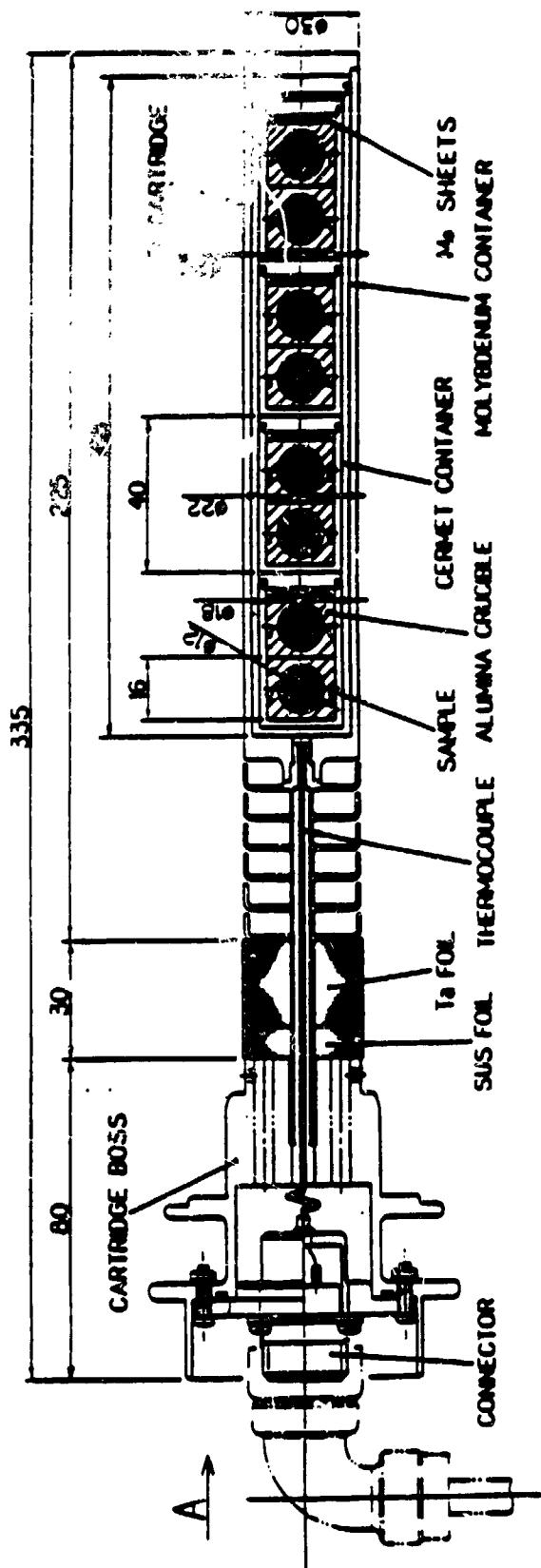


FIGURE 15 LIJF-MP FUNCTIONAL DIAGRAM



ORIGINAL PAGE IS  
OF POOR QUALITY

Figure 16 F0 MOS Sample

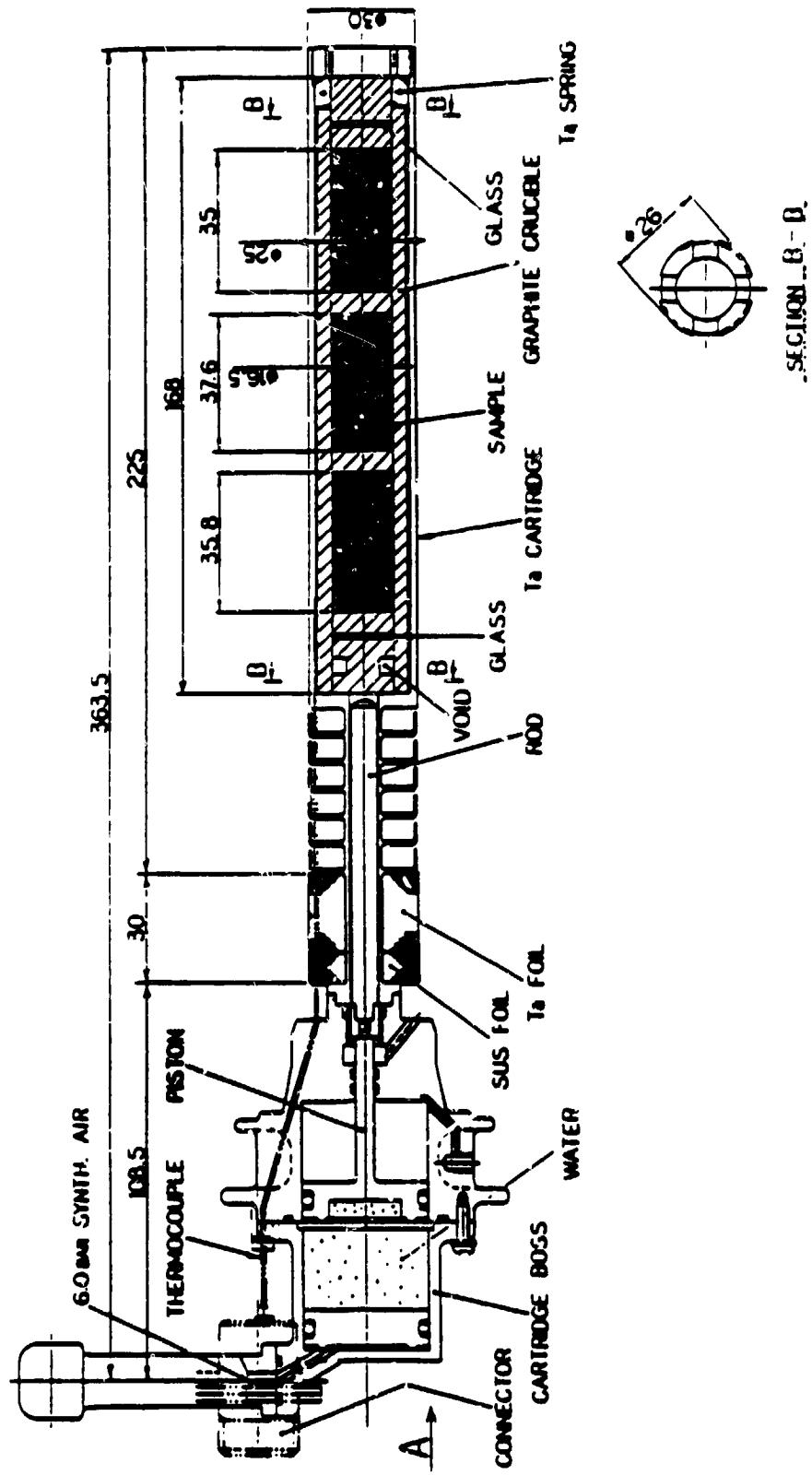


Figure 17 F0 M06 Sample

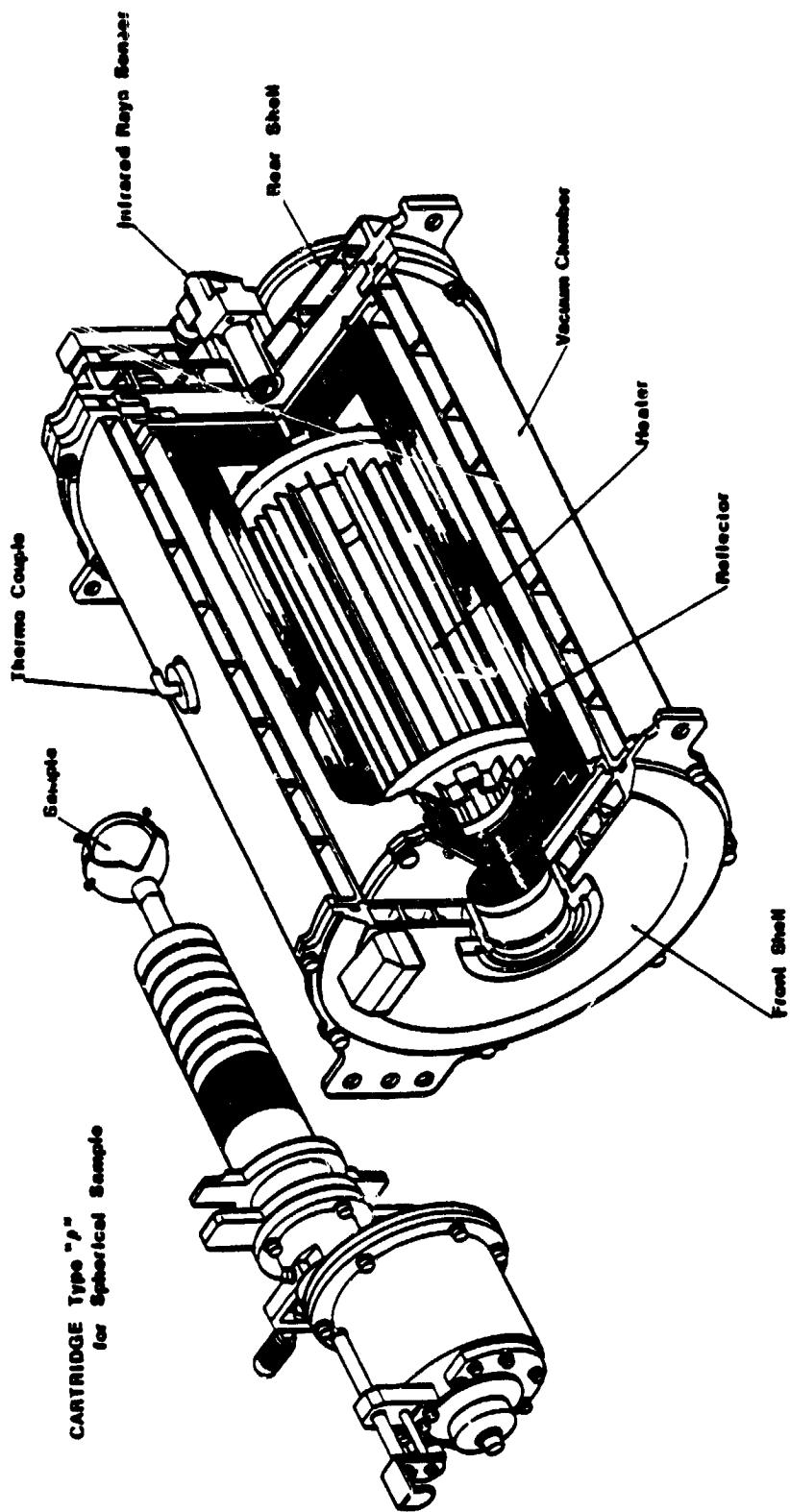


FIGURE 18 CRYSTAL GROWTH EXPERIMENT FACILITY CONCEPT (1/2)  
(FOR SPHERICAL SAMPLE)

ORIGINAL PAGE IS  
OF POOR QUALITY

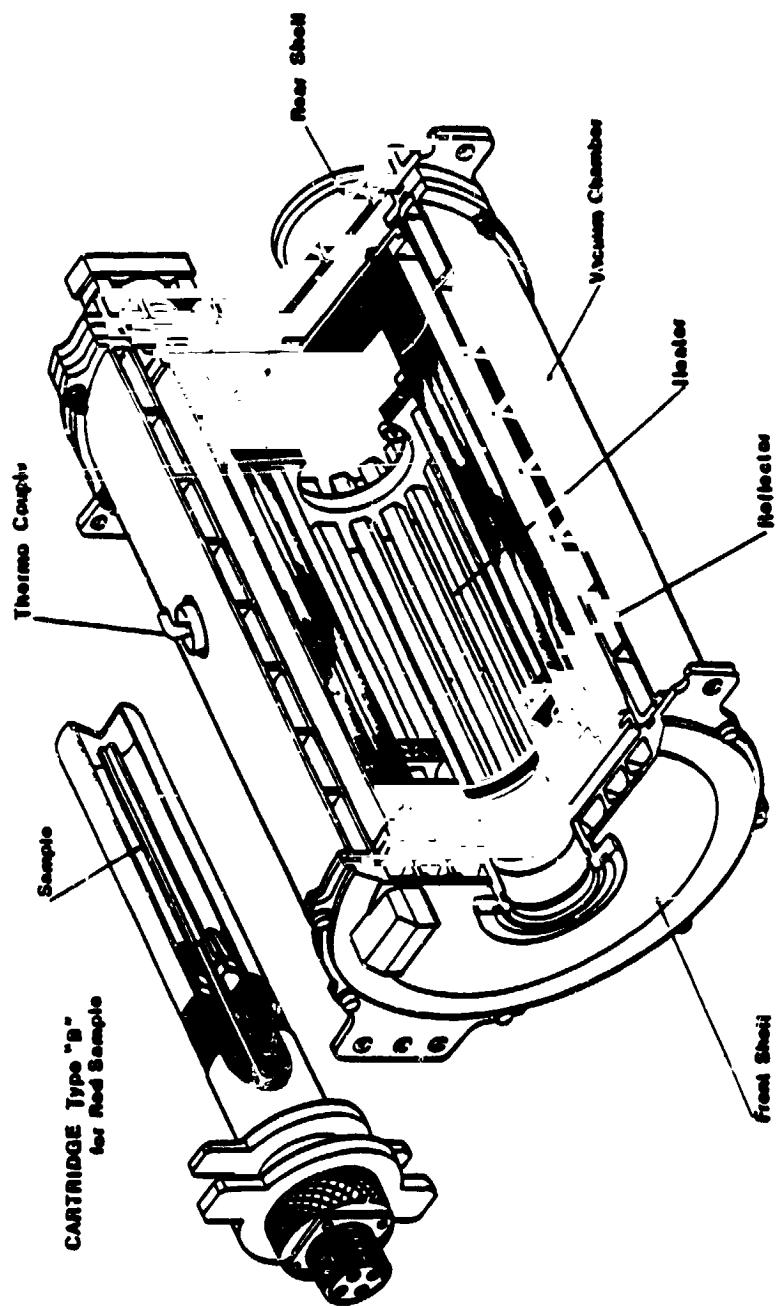


FIGURE 19 CRYSTAL GROWTH EXPERIMENT FACILITY CONCEPT (2/2)  
(FOR ROD SAMPLE)

Table 7 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC <sub>3</sub> (mg/m <sup>3</sup> )	Containment
M 09 CGF	SI		1450	2	Unsealed Ball Sample Unsealed Rod Sample
M 17 ALF	CaO	a b c	1400	0.4	** Naked
	CaO	a b c		1.4	
	GeO	a b c		85.6	
	total	a. b. c.			

\*\* Does Not Exceed SMAC

### Acoustic Levitator Furnace (ALF)

The ALF, Figure 20, is designed for containerless refinement of glass in space. The ALF, which operates at approximately 1400°C, is very similar to the Image Furnace in that halogen lamps, located at the focii of twin ellipsoid mirrors reflect the heat to a common focus point for melting glass. The ALF sample is processed in a krypton gas flow which is at a negative pressure in relation to the module pressure. The pressure is continuously monitored and the furnace is automatically shut down if the internal pressure approaches ambient pressure. The furnace is equipped with a speaker to create an ultrasonic tunnel within the furnace. A sound reflector at the rear of the furnace is adjustable to enable sample positioning. The furnace will process sample M 17 of Table 7 which is a naked glass sample. Toxicity is low and containment will be provided by the furnace and the vacuum vent.

### Organic Crystal Growth Facility (OCF)

The OCF Figure 21 is comprised of two experiment cells, a large cell and a small cell. Contents of the small cell are insufficient to result in a toxicity hazard and is controlled by dual containment. Both cells are processed at room temperature. The large cell uses an inner quartz container which has three chambers, one for the donor fluid, one for mixing and one for the acceptor fluid. The anisole, Table 8, is toxic and due to the quantity will require triple containment. The quartz container is located within an aluminum container which is housed in a sealed aluminum box. The quartz container and the inner box have some common penetrations. In order to achieve two containments, it is necessary to use dual sets of "o" rings or seals. A vigorous qualification program including a 14 month leak test is being performed.

### Other Processing Facilities

Other experiments include a Bubble Behavior Unit to study fluid movement in space, A Marangoni Convection Unit, a Liquid Drop Facility (acoustic levitation) for fluid drops and a Gas Evaporation Facility. Single or dual containment is provided as required. The containments are interesting, however the experiments do not provide significant toxicity hazards.

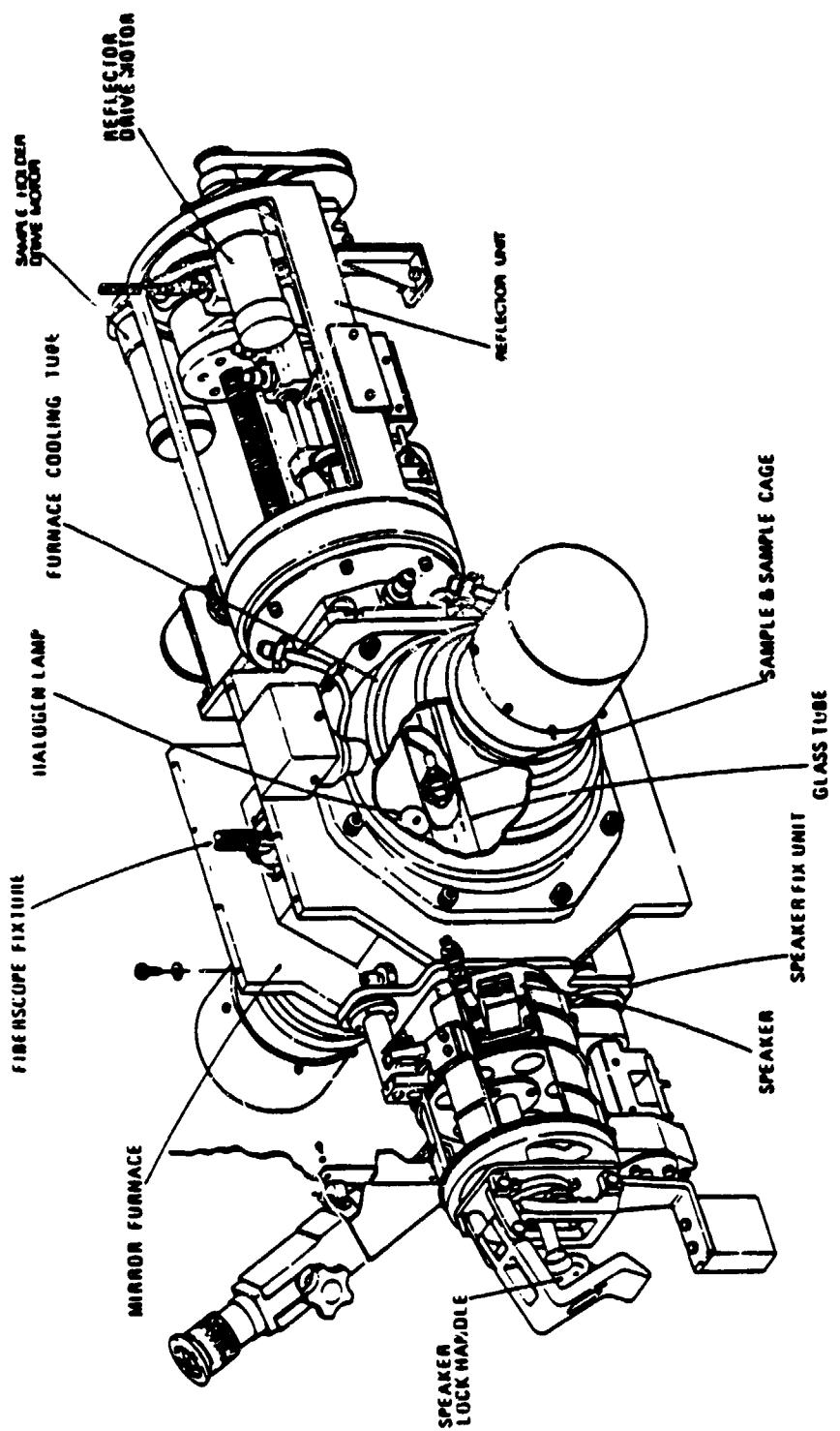


FIGURE 20 ALF-LVT FURNACE

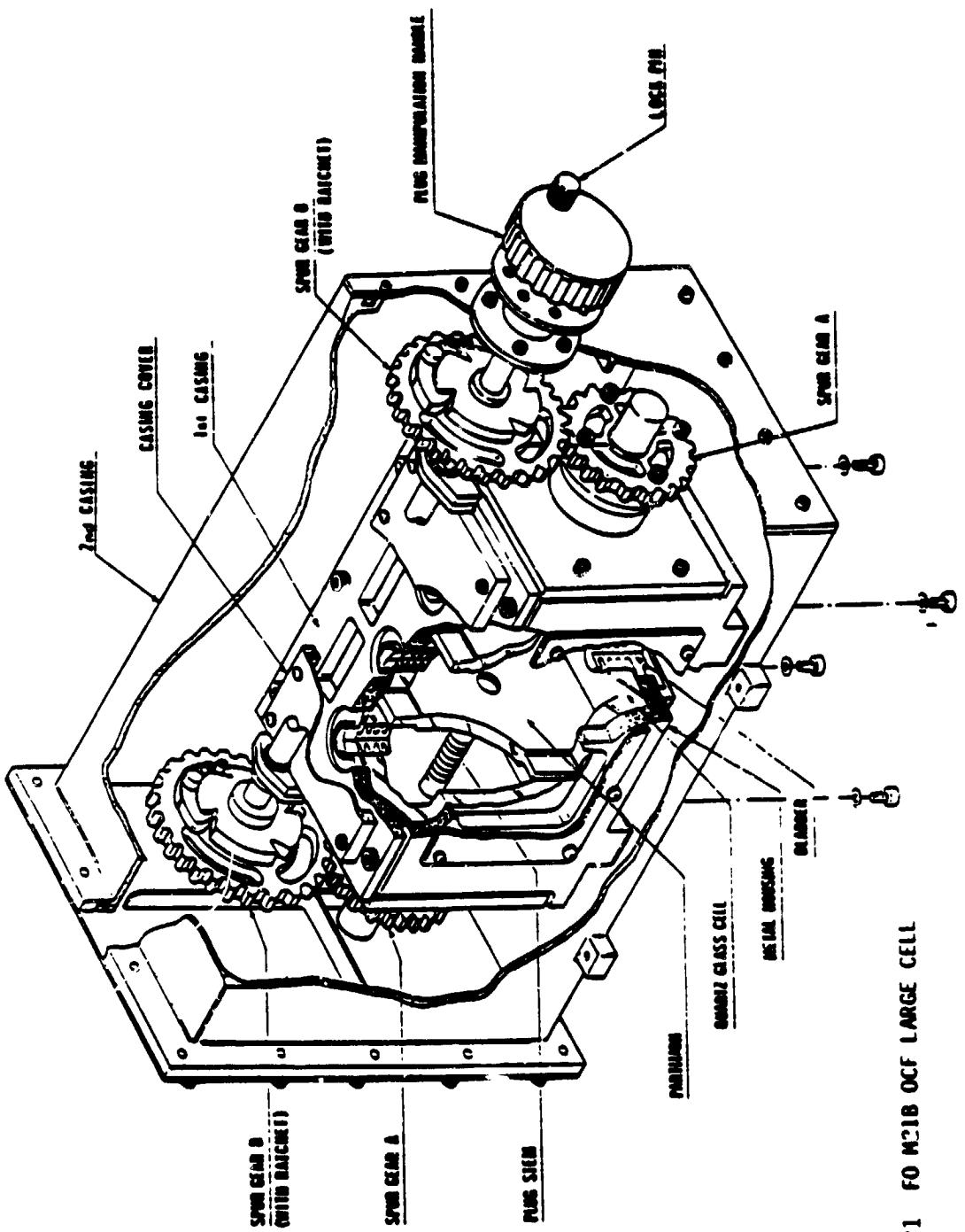


FIGURE 21 F0 M21B OCF LARGE CELL

Table 8 FMPT - MEL SAMPLE DATA

Experiment /Equipment	Ingredients	Quantity (g)	Process Temperature °C	SMAC (mg/m <sup>3</sup> )	Containment
M21A OCF	Anisole TMTTF TCNQ TMTTF-TCNQ Au	<u>3.3047±0.3</u>	AMBIENT	8.8 ? ? ? 1	2 Containments Small Cell Qtz. Cell Alum. Case
M21B OCF	Anisole TMTTF TCNQ TMTTF-TCNQ Ag	<u>221.2902</u>	AMBIENT	8.8 ? ? ? 1	3 Containments Large Cell Qtz Cell Alum. Case Sealed Box

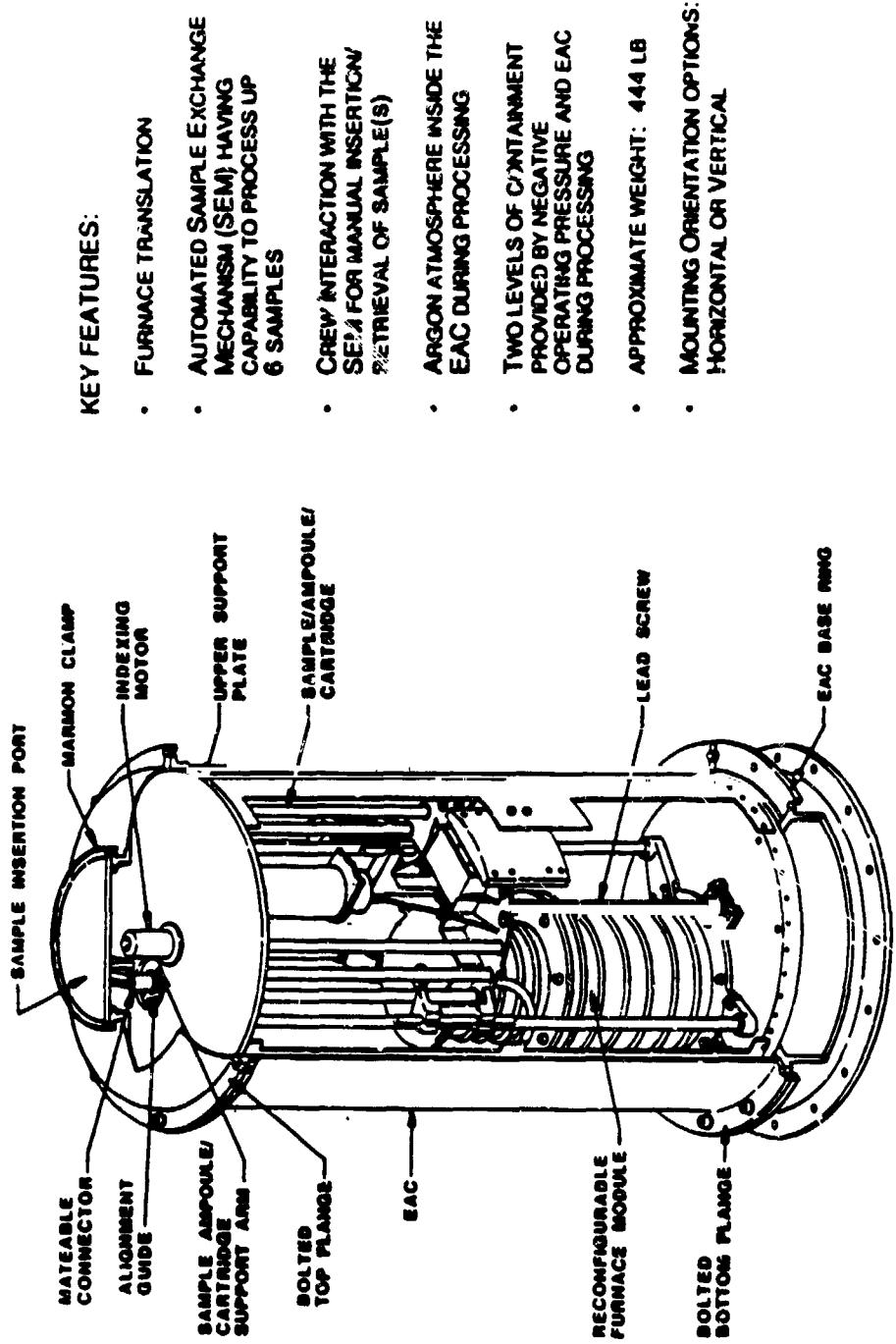
## USML-1 Spacelab

The USML-1 is still in the early design stages and concepts are not as clearly defined as Spacelab J. There will be several material processing facilities including containerless processing by acoustic levitation. Another experiment will be the Crystal Growth Facility, Figure 22, which will process numerous toxic metals at different temperatures. This facility will have some direct bearing on the space station. The facility uses a furnace core which translates along the sample axis. As in the case of some SL-J experiments, the Crystal Growth Facility will use the vacuum vent as a level of containment and will require shut down if the inner pressure becomes positive in relation to the module. Sample change out will be manually performed by the crew. To preclude toxic material release in the module during sample change out, a collapsible glove box will be used. The glove box will seal around the end of the container while the insertion port cover is removed. In the event of toxic residue in the furnace as evidenced by discolorization the cover will be reinstalled and the glove box dumped to the vacuum vent.

## Recommendations/Conclusions

- ° Triple containment is the preferred method for prevention of toxic material release in habitable areas for catastrophic hazards. The containments must be adequate for the intended use and environment.
- ° When operations preclude triple containment, innovative methods should be explored. While there are several examples of use of the vacuum vent as an equivalent containment, stringent requirements exist to monitor internal pressures and shut the facility down for positive pressure. Materials must be nontoxic at ambient temperatures, and offgassed products must be compatible with the vacuum vent. Offgassed products must also be compatible with each other to the extent that exothermic reactions must not occur which would result in a hazard. It should be noted that a contaminated vacuum vent could result in ground hazards during de-integration activities and will require special procedures. It is usually the responsibility of the experiment developer to decontaminate or replace the vacuum vent after flight.

### CGF INTEGRATED FURNACE/EAC ASSEMBLY



CRYSTAL GROWTH FURNACE (CGF)

FIGURE 22

# **SOVIET MATERIALS PROCESSING EXPERIENCE AND EQUIPMENT**

**NICHOLAS L. JOHNSON  
ADVISORY SCIENTIST  
TELEDYNE BROWN ENGINEERING**

**29 NOVEMBER 1988**

**SPACE STATION TOXIC AND REACTIVE  
MATERIALS HANDLING WORKSHOP**

**HUNTSVILLE, ALABAMA**

**TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910**

THE8810-497

# SCOPE OF PRESENTATION

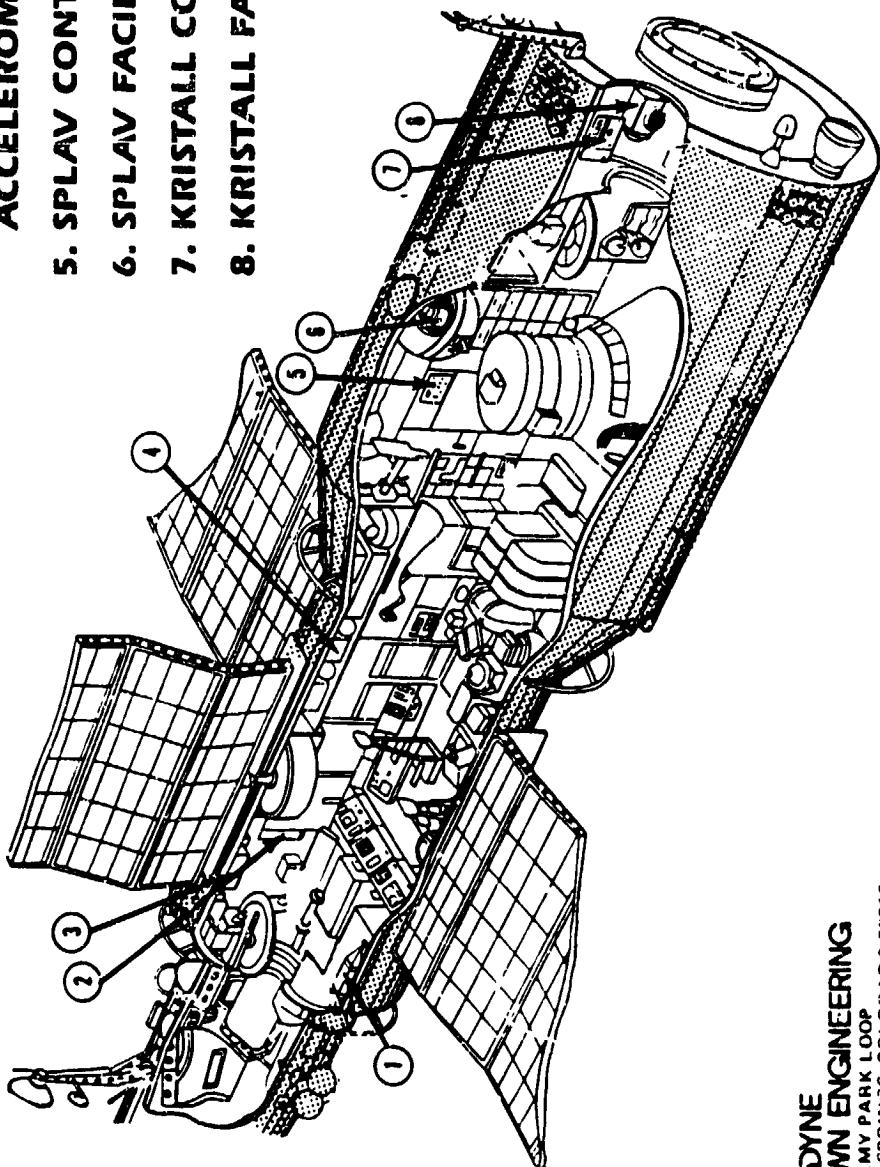
TRK 0010-498

- SOVIET SPACE STATION CONFIGURATIONS
- MATERIALS PROCESSING EQUIPMENT
  - ELECTRIC FURNACES
  - BIOTECHNOLOGICAL UNITS
- OPERATIONAL PROBLEMS ENCOUNTERED
- PHOTON UNMANNED MATERIALS PROCESSING  
SPACECRAFT AND EQUIPMENT
- SUMMARY

# SALYUT SPACE STATION MATERIALS SCIENCE LAYOUT

1000010-499

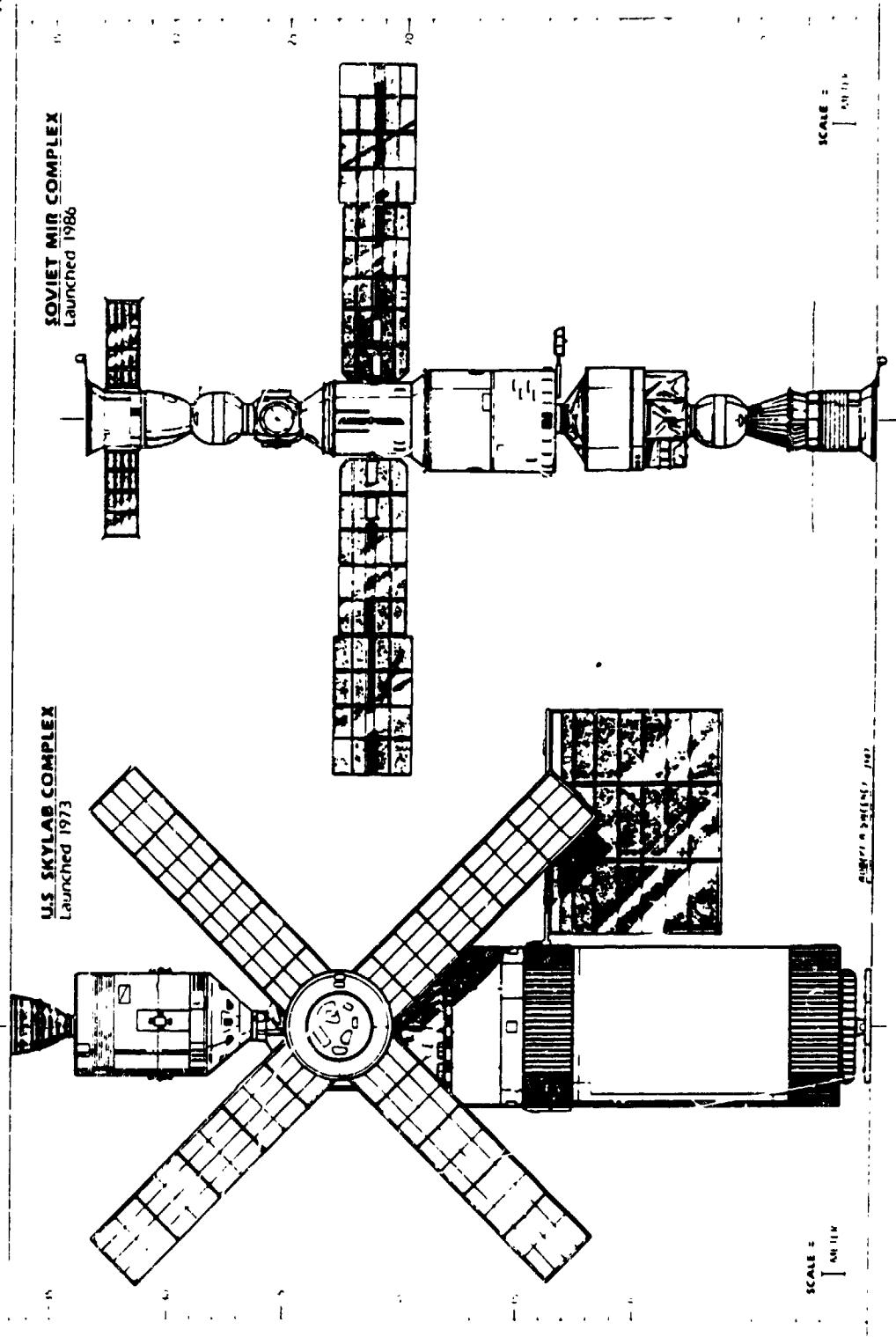
1. PION FACILITY
2. TAVRIYA FACILITY
3. GENOM FACILITY
4. TRIF. XIAL HIGH-SENSITIVITY  
ACCELEROMETER
5. SPLAV CONTROL PANEL
6. SPLAV FACILITY
7. KRISTALL CONTROL PANEL
8. KRISTALL FACILITY



TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

# MIR SPACE STATION PRESENT CONFIGURATION

TELE010-500



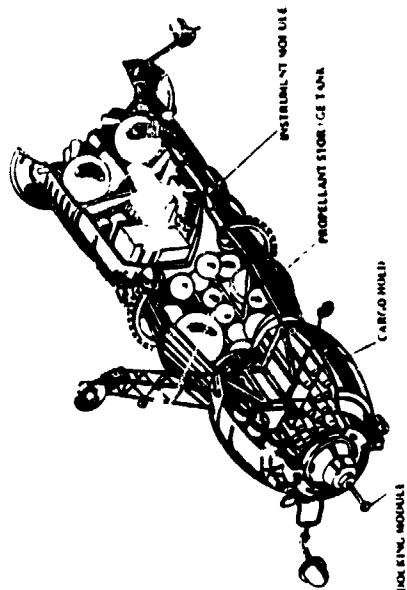
TELEDYNE  
BROWN ENGINEERING,  
1250 ACADEMY PARK LOOP  
LITTLETON, COLORADO 80110

ORIGINAL PAGE IS  
OF POOR QUALITY

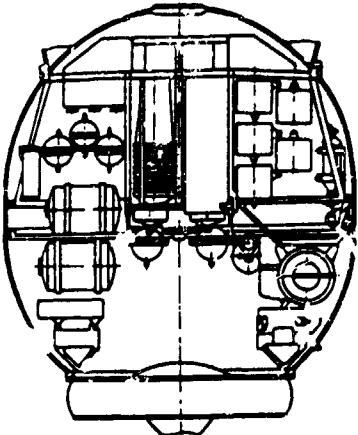
# PROGRESS UNMANNED RESUPPLY SPACECRAFT

THESS10-501

- SPECIFICATIONS
  - SUCCESSFUL MISSIONS SINCE 1978: 38
  - CURRENT FLIGHT RATE: ~6 PER YEAR
  - MEAN LIFETIME: 34 DAYS (MINIMUM = 14  
MAXIMUM = 74)
- TOTAL MASS: 7,020 kg
- PAYLOAD MASS: 2,300 kg
- (CARGO HOLD = 1,300 kg)  
(STORAGE TANKS = 1,000 kg)
- NOT RECOVERED



## PROGRESS SPACECRAFT

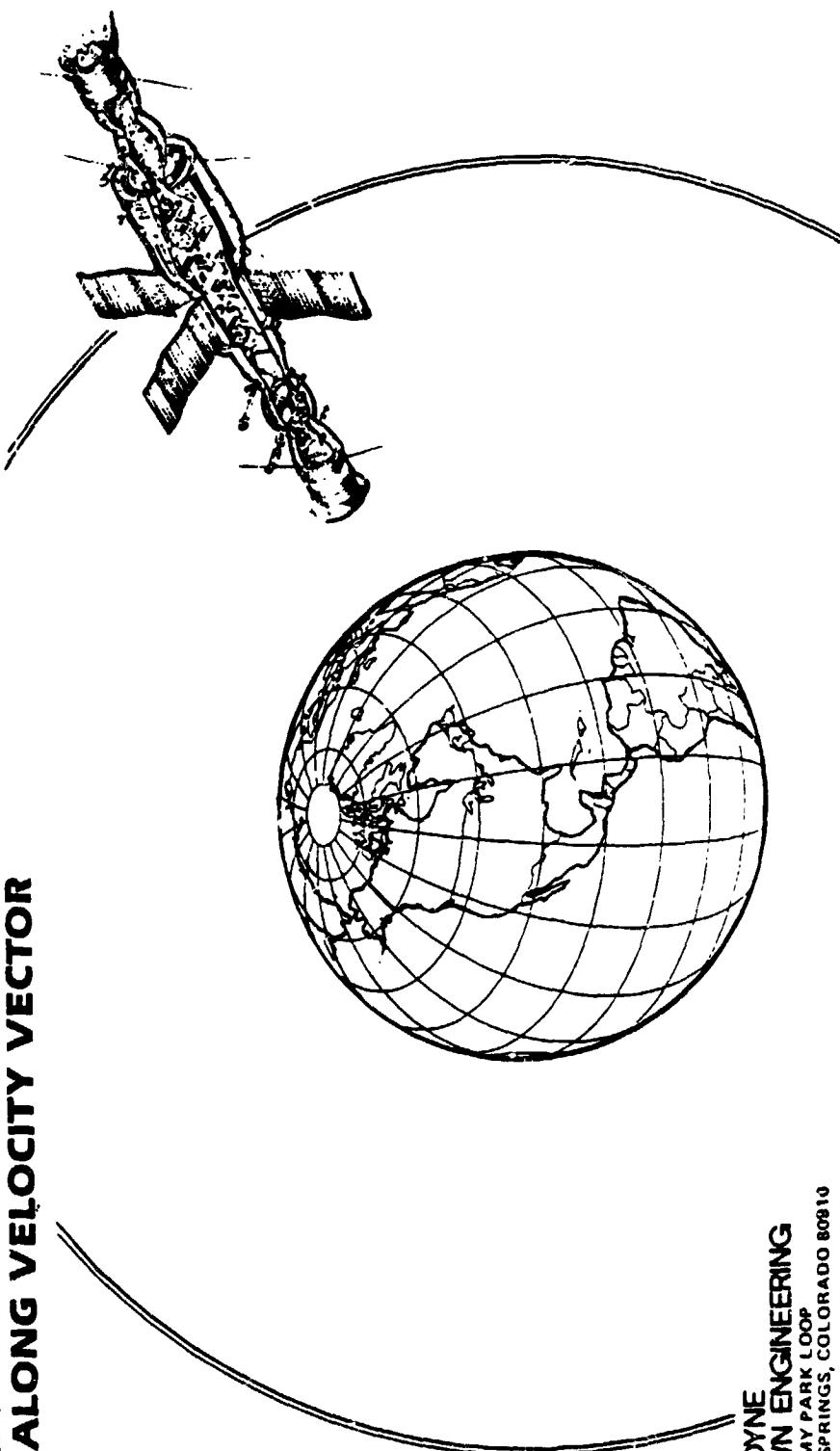


## PROGRESS 2 CARGO CONFIGURATION

# SPACE STATION STABILIZATION

708810-502

- GRAVITY-GRADIENT STABILIZATION USED FOR MOST MATERIALS PROCESSING EXPERIMENTS
- ROTATIONAL MODES ( $\leq 0.4^\circ/\text{SEC}$ ) ALSO TRIED DURING GRAVITY-GRADIENT REGIMES
- SPACE STATION USUALLY ORIENTED WITH LONGITUDINAL AXIS ALONG VELOCITY VECTOR

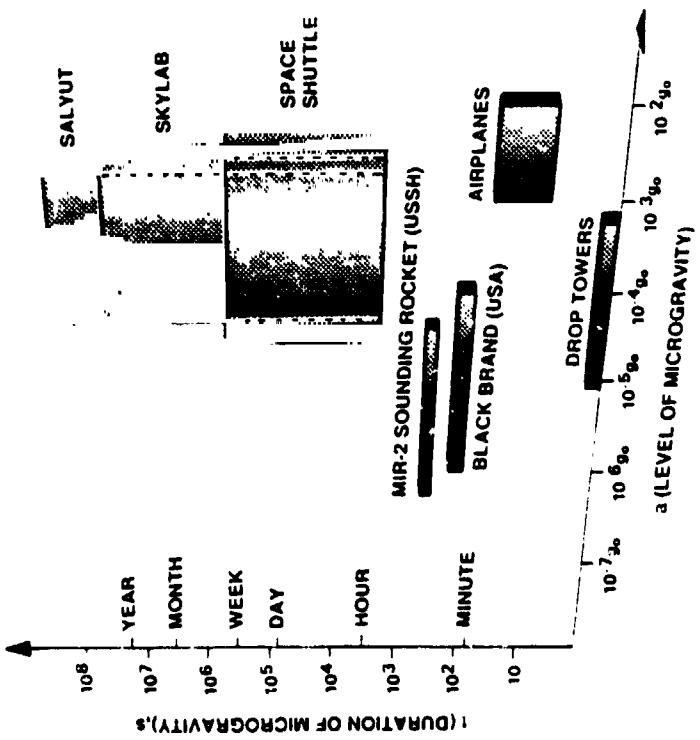


# SOVIET MEASUREMENTS OF MICROGRAVITY CONDITIONS

TELE10-503

## LOW-FREQUENCY ACCELERATION LEVELS UNDER VARIOUS FLIGHT CONDITIONS

PARTICULARS	LOAD FACTOR, g/10		
	X-AXIS	Y-AXIS	Z-AXIS
UNMANNED PROGRESS MISSION	$1 \times 10^{-5}$ $-1 \times 10^{-6}$	$1 \times 10^{-5}$ $-1 \times 10^{-6}$	$1 \times 10^{-5}$ $-1 \times 10^{-6}$
NORMAL CREW ACTIVITY ON SALYUT-6	$10^{-1} \cdot 10^{-5}$	$10^{-3} \cdot 10^{-5}$	$10^{-3} \cdot 10^{-5}$
OPERATION OF KASKAD ATTITUDE CONTROL SYSTEM	$2 \times 10^{-4}$	$2 \times 10^{-4}$	$5 \times 10^{-4}$
WITH CREW DOING PHYSICAL EXERCISES	$10^{-4}$	$1 \times 10^{-3}$ $-1 \times 10^{-2}$	$1 \times 10^{-3}$ $-1 \times 10^{-2}$



- ACCELEROMETERS NOW FOUND ON MIR AND WITHIN MATERIALS PROCESSING EQUIPMENT

- $5 \times 10^{-7}$  g<sub>0</sub> POSSIBLE WHEN COSMONAUTS ASLEEP

# ELECTRIC FURNACES ON SOVIET SPACE STATIONS

788810-504

DEVICE	LAUNCHED ON	OPERATED ON	OPERATIONAL PERIOD	MASS (kg)	POWER (kw)	CARTRIDGE SIZE (mm)	CARTRIDGE CAPACITY	MAXIMUM TEMPERATURE (°C)	VENT TO SPACE
SFERA	SALYUT 5	SALYUT 5	1976	7	10	7	7	<100	N
SPLAV 1	PROGRESS 1	SALYUT 6	1978-91	23	300	170 x 20.8	1	850	Y
KRISTALL (1)	PROGRESS 2	SALYUT 6	1978	27	250	175 x 13	1	1,000	N
KRISTALL (2)	PROGRESS 5	SALYUT 6	1979-91						
MAGMA-F (KRISTALL MOD)	PROGRESS 13	SALYUT 7	1982-86	28	250	240 x 21	1	1,000	N
KORUND-1	PROGRESS 14	SALYUT 7	1982	130	720	310 x 33	12	1,270	N
PION-M*	PROGRESS 17	SALYUT 7	1983	41	<100	140 x 140	1	100	N
KRISTALLIZATOR	KOSMOS 1628	SALYUT 7	1985-88	41	300	140 x 15.8	19	970	N
KORUND-1M	PROGRESS 28	MIR	1997	136	1,000	310 x 33 (7)	6	1,270	N
KRISTALLIZATOR	PROGRESS 30	MIR	1997	41	300	140 x 15.8	19	970	N
"MIRROR-EAM"	PROGRESS 33	MIR	1997	1	250	7	7	1,000	?

\* NOT PRIMARY AN ELECTRIC FURNACE: USED IN 1983 TO GROW CRYSTALS BY STEPANOV METHOD. UNIT TRANSFERRED TO MIR IN 1986 BY SOYUZ T-15

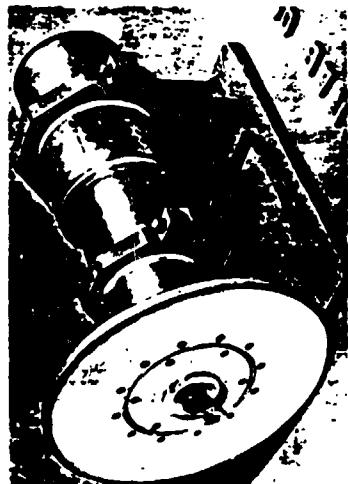
TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

## SPLAV 1 DESIGN

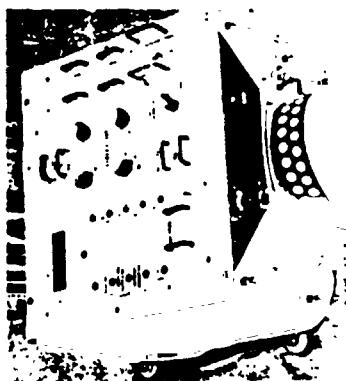
TELE 810-505

- SPLAV 1 ONLY MATERIALS  
PROCESSING DEVICE VENTED TO  
SPACE (FOR HEAT DISSIPATION)
- VENTING NOW DISCOURAGED DUE  
TO CREW SAFETY CONCERN

ELECTRIC FURNACE



CONTROL UNIT



ORIGINAL PAGE IS  
OF POOR QUALITY



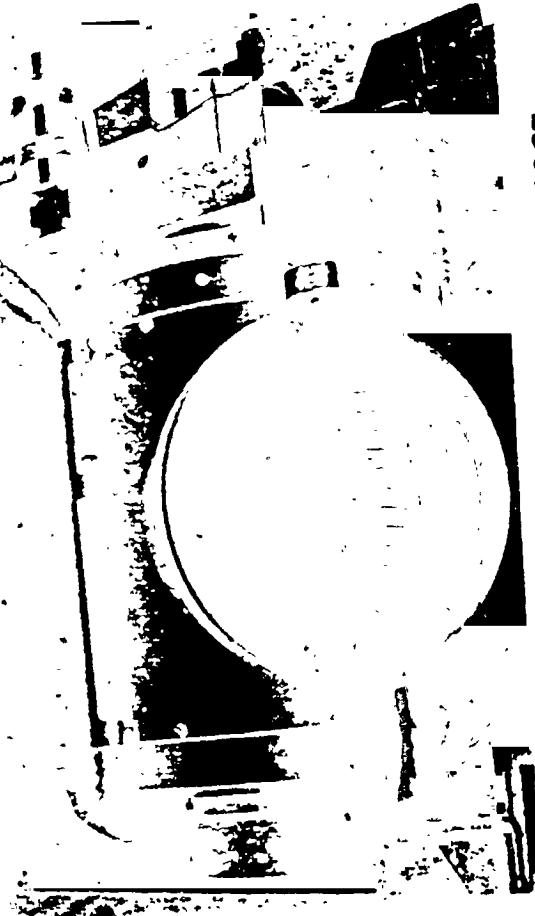
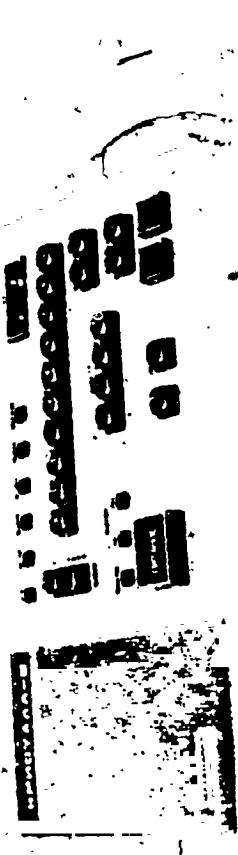
1980 EXPERIMENT ON SALYUT 6

TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

# KRISTALL FAMILY OF FURNACES

TELE010-504

- THREE GENERATIONS
  - KRISTALL: 1978
  - MAGMA-F: 1982
  - KRISTALLIZATOR: 1985



- USED FOR EARLY SCIENTIFIC INVESTIGATIONS OF MICROGRAVITY INFLUENCES
- KRISTALLIZATOR NOW IN USE ON MIR IS A SOVIET-CZECH DESIGN LED BY L.L. REGEI; CAPACITY OF 19 SAMPLES GREATLY REDUCES CREW INTERACTION TIME

9-10

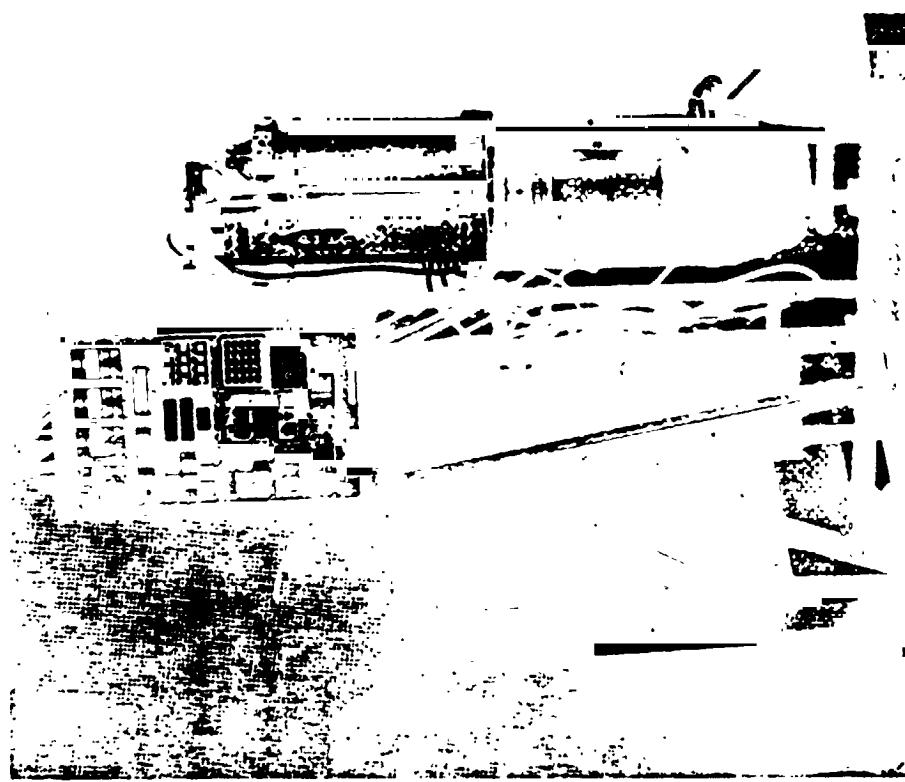
ORIGINAL PAGE IS  
OF POOR QUALITY

ORIGINAL KRISTALL ELECTRIC FURNACE

TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

# KORUND PILOT-PRODUCTION FURNACES

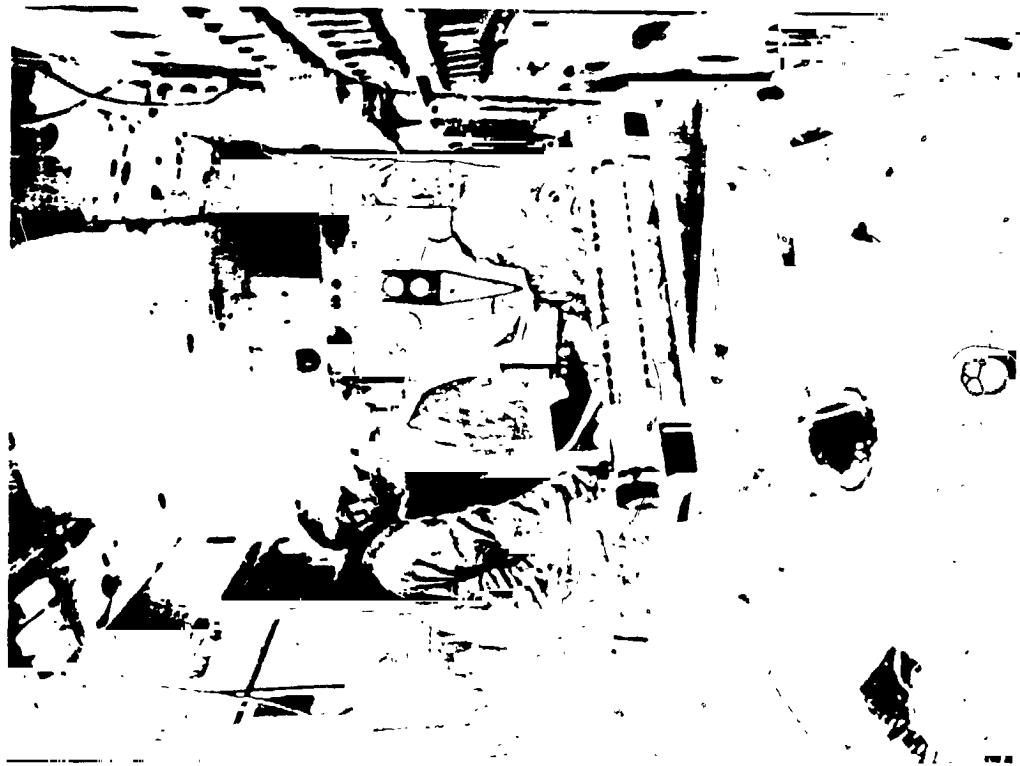
TELE10-507



- KORUND-1
  - USED SPARINGLY ON SALYUT 7 IN 1982
- KORUND-1M
  - DELIVERED TO MIR IN 1987
  - SAMPLES:  $\leq 25$  mm DIAMETER  
 $\leq 1.5$  kg
  - DURATION OF EXPERIMENTS:  
6-150 hr
  - PRIMARILY FOR  
"SEMICONDUCTOR" MATERIALS

# BIOTECHNOLOGY UNITS ON SOVIET SPACE STATIONS

TS58010-508



UNIT	TYPE	SPACE STATION	DEBUTED
TAVRIYA	ELECTROPHORESIS	SAIYUT 7	1982
GENOM	ELECTROPHORESIS	SAIYUT 7	1984
EFU ROBOT	ELECTROPHORESIS	SAIYUT 7	1985
	(TRANSFERRED TO MIR IN 1986)		
SVETLANA	ELECTROPHORESIS	MIR	1987
RUCHEV	ELECTROPHORESIS	MIR	1987
AYNUR	PROTEIN CRYSTALLIZATION	MIR	1987

ORIGINAL PAGE IS  
OF POOR QUALITY

# OPERATIONAL PROBLEMS ENCOUNTERED

## ● MICROGRAVITY CONDITIONS

- MANY MATERIALS PROCESSING EXPERIMENTS DETERIORATE AT  $a \geq 10^{-3} g_0$
- DIFFICULT TO MAINTAIN  $a < 10^{-3} g_0$  FOR LONG PERIODS (DAYS) WITH CREW ON BOARD. DAILY EXERCISE REGIME PRESENTS DIRECT CONFLICT
- $a$  LEVELS ENHANCED IN GRAVITY-GRADIENT STABILIZATION MODE, BUT THIS ORIENTATION CONFLICTS WITH EARTH AND DEEP-SPACE OBSERVATIONS

## ● QUANTITY OF RETURNED PROCESSED MATERIALS

- PROCESSED MATERIALS MUST COMPETE WITH OTHER EXPERIMENT RESULTS (E.G. NATURAL RESOURCES AND ASTROPHYSICAL FILM CANISTERS) FOR LIMITED SOYUZ TM RETURN PAYLOAD CAPACITY, I.E. 120-150 KG
- KOSMOS 1443-TYPE RETURN CAPSULE HAD CAPACITY OF 500 KG, BUT THE SYSTEM WAS SINGLE-USE AND HAS NOT BEEN EMPLOYED SINCE 1983

# OPERATIONAL PROBLEMS ENCOUNTERED (CONTINUED)

TM0011-511

- FREQUENCY OF RETURNED PROCESSED MATERIALS
  - RETURN OF MATERIALS NOW LIMITED TO 2-3 TIMES PER YEAR WITH SOYUZ TM CREWS
  - CONSEQUENTLY, ELECTROPHORESIS EXPERIMENTS ARE NORMALLY CONDUCTED IMMEDIATELY PRIOR TO OR DURING SOYUZ TM VISITATIONS (NOTE a LEVELS MAY INCREASE WITH TEMPORARY CREW AUGMENTATIONS)
- TEMPERATURE CONTROL
  - MAINTENANCE OF PRESCRIBED TEMPERATURES ARE HINDERED BY POWER FLUCTUATIONS DURING DAYLIGHT-NIGHTTIME PORTIONS OF ORBIT
  - AVAILABLE POWER ALSO AFFECTED BY SUN-ORBIT PLANE ANGLE (INCLINATION =  $51.6^\circ$ ) AND BY LIMITED SOLAR PANEL ARTICULATION
  - TEMPERATURE UNIFORMITY WITHIN SAMPLE

 **TELEDYNE  
BROWN ENGINEERING**  
1750 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

# OPERATIONAL PROBLEMS ENCOUNTERED (CONCLUDED)

TELE 10-511

## ● HEAT REJECTION

- ALL MATERIALS PROCESSING UNITS SINCE SMALL SPLAV 1 FURNACE MUST REJECT HEAT INTO SPACE STATION CABIN
- INSTRUMENT OVERHEATING AND/OR UNCOMFORTABLE CREW ENVIRONMENTAL CONDITIONS MAY RESULT

## ● GENERAL VS- SPECIFIC PURPOSE DEVICES

- INITIAL TREND TOWARD GENERAL (MULTI) PURPOSE DEVICES TO ADVANCE KNOWLEDGE OF WIDE RANGE OF MICROGRAVITY EFFECTS; CONSEQUENTLY, EXPERIMENT SELECTION WAS SOMETIMES DRIVEN BY INSTRUMENT CAPABILITIES, E.G. KRISTALL FURNACE
- LARGER, SPECIAL PURPOSE DEVICES NOW BEING PRODUCED FOR LIMITED MANUFACTURING

TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LANE  
COLORADO SPRINGS, COLORADO 80910

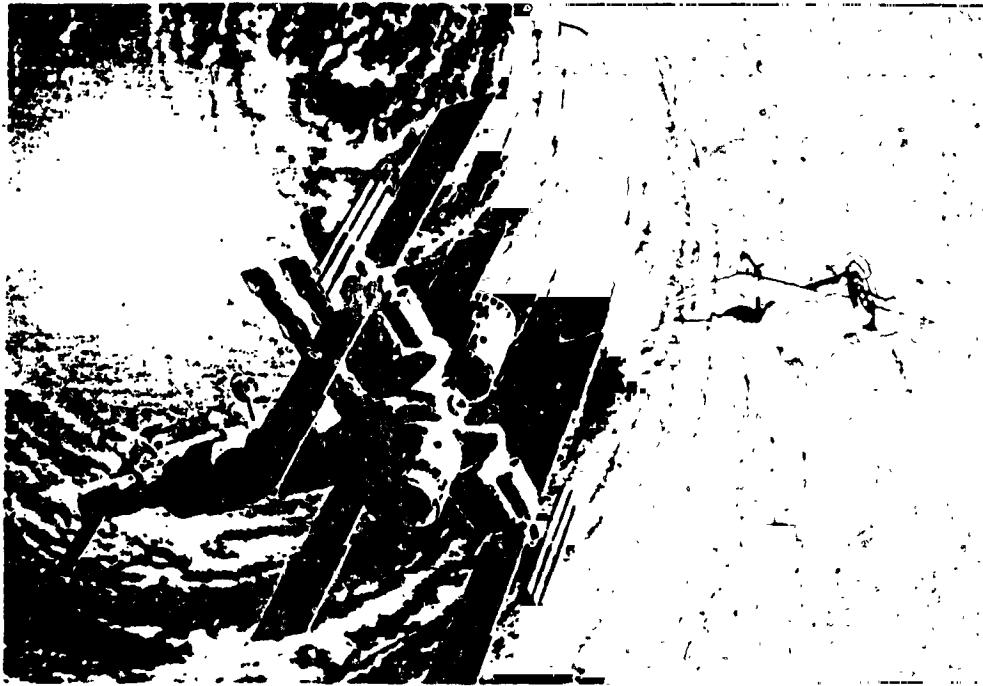
# FUTURE OF SOVIET MATERIALS PROCESSING ON MANNED SPACE STATIONS

TBEE810-512

- NEW DEDICATED MATERIALS PROCESSING MODULE EXPECTED IN 1989
- LARGER CAPACITY INSTALLATIONS

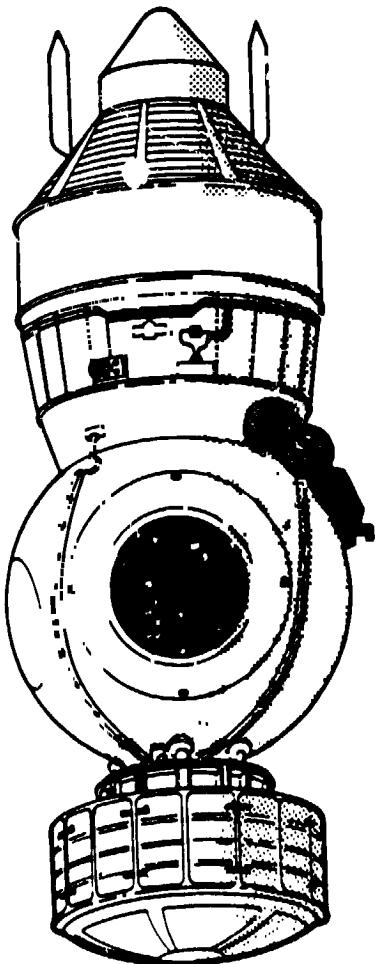
DEVICE	SAMPLE DIAMETER
ORION	25 mm
DYUNA	40 mm
KRATER	50 mm
MENISK	50 mm

- ISSUES
  - STATION STABILIZATION
  - FREE-FLYING MODULE OPERATIONS



# PHOTON MATERIALS PROCESSING SPACECRAFT

T8E911-5913

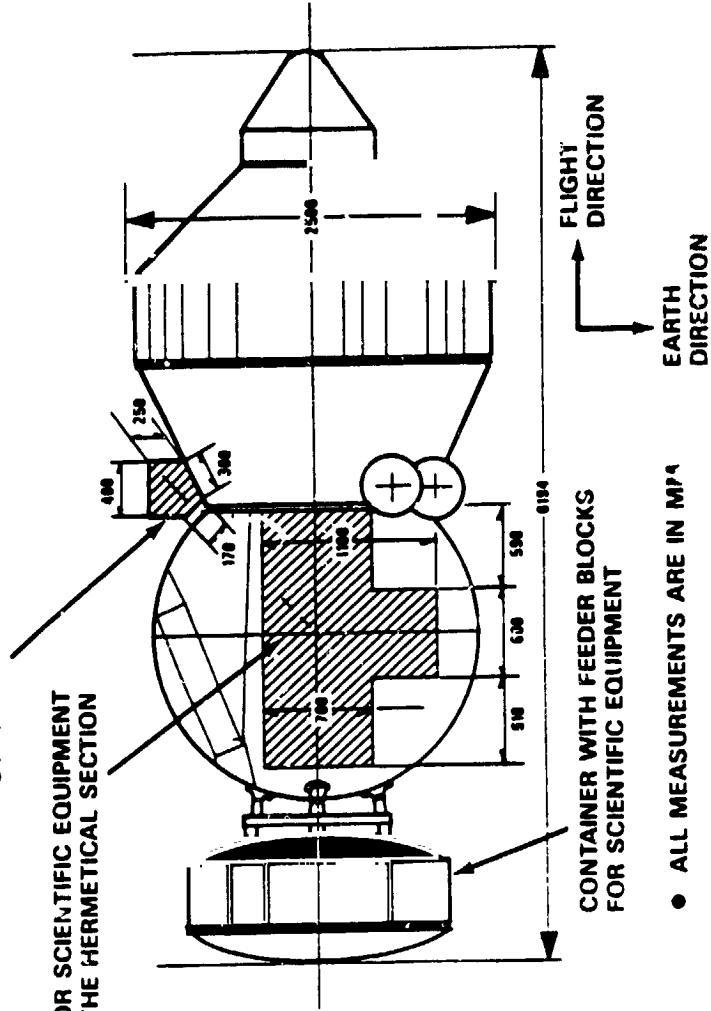


• LAUNCHED ANNUALLY  
• EACH SPRING SINCE 1985

- OFFERED ON A COMMERCIAL BASIS AT \$15,000 PER KG PAYLOAD

## AREA FOR THE SCIENTIFIC EQUIPMENT OUTSIDE THE STATION

## AREA FOR SCIENTIFIC EQUIPMENT INSIDE THE HERMETICAL SECTION



## CONTAINER WITH FEEDER BLOCKS FOR SCIENTIFIC EQUIPMENT

- ALL MEASUREMENTS ARE IN MM

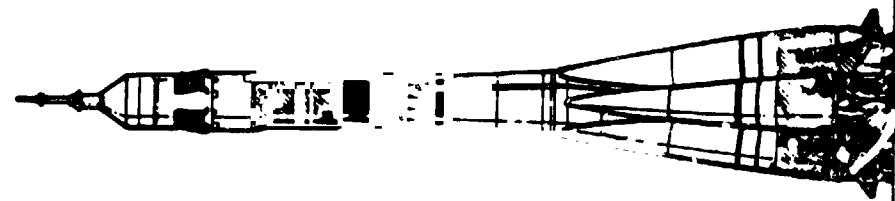
EARTH  
DIRECTION

**TELEDYNE**  
**BROWN ENGINEERING**  
1250 ACADEMY PARK LN. OP  
COLORADO SPRINGS, COLORADO 80910

# PHOTON SPACECRAFT SPECIFICATIONS

TE8810-514

- FLIGHT DATA
  - LAUNCH VEHICLE: SOYUZ, SL-4
  - FLIGHT DURATION: 14-30 DAYS
  - INCLINATION: 62.8°
  - APOGEE: 300-400 KM
  - PERIGEE: 220-250 KM



- PAYLOAD DATA
  - MASS: 500 kg
  - VOLUME: 4.7 m<sup>3</sup>
  - AVERAGE DAILY POWER: 400 W
  - PEAK DAILY POWER (1.5 HR/DAY): 700 W
  - IN-FLIGHT DATA TELEMETRY/COMMANDS PERMITTED
  - PAYLOAD RETURNED WITHIN 24 HR OF LANDINGS
  - MPUS AVAILABLE: ZONA 1, SPLAV 2, KASHTAN
  - MICROGRAVITY LEVELS RECORDED
- PROCURED FLIGHTS
  - KAYSER-THREDE (WEST GERMANY): THREE FLIGHTS BEGINNING IN 1989-1990; 50-60 kg PAYLOAD FIRST FLIGHT; 80-100 kg PAYLOAD FOR SECOND AND THIRD FLIGHTS
  - CNES (FRANCE): ONE FLIGHT IN 1989; 20-30 kg PAYLOAD

TELEDYNE  
BROWN ENGINEERING  
1750 ACADEMY PARK LOOP  
COLORADO SPRINGS, COLORADO 80910

SL-4

# SOVIET MATERIALS PROCESSING UNITS

TE80011-584



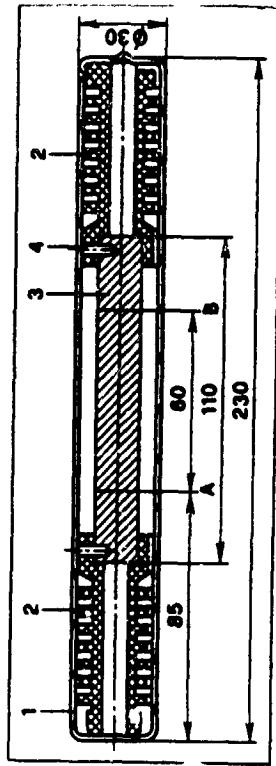
**ZONA 1**

**SPLAV 2**

ORIGINAL PAGE IS  
OF POOR QUALITY

# ZONA 1 SPECIFICATIONS

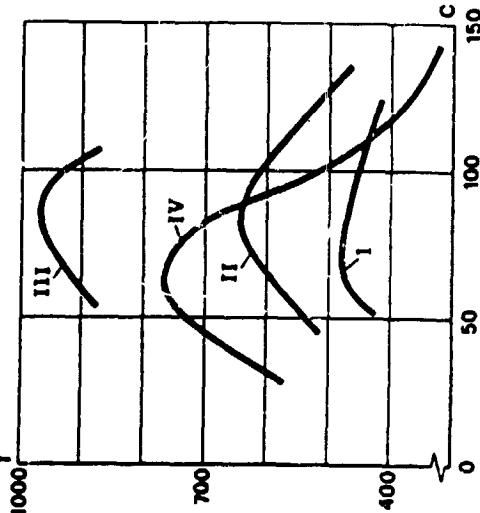
TELENO-516



## RESEARCH AMPOULE IN THE ZONA 01 UNIT

1 - housing; 2 - graphite holder; 3 - material being studied; 4 - retaining pin.  
 A - initial position; B - final position of the ampoule during operation.

Chart of temperature distribution over the ampoule length depending on the  
 heater  
 (I, II, III and IV—types  
 of heaters).  
 T - temperature, °C  
 C - length, mm.



BASIC SPECIFICATIONS OF THE ZONA 01 UNIT	
Spacecraft.....	Photon
Year of Introduction.....	1985
Mass, kg.....	90
Power Required, W.....	300
DIMENSIONS OF OBTAINED SAMPLE, mm:	
length.....	0
diameter.....	15
Thermal characteristics, °C:	
heating temperature.....	400—1,070
temperature increment.....	5
specified temperature accuracy.....	±5
temperature maintenance accuracy.....	±1
Maximum time of temperature maintenance prior to advance, h.....	2
Advance speed, mm/h.....	1-15

TELEDYNE  
 BROWN ENGINEERING  
 1750 ACADEMY PARK LOOP  
 COLORADO SPRINGS, COLORADO 80910

# SPLAV 2 SPECIFICATIONS

TE88010-517

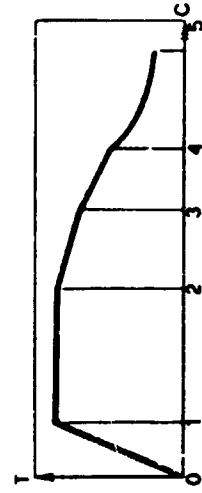
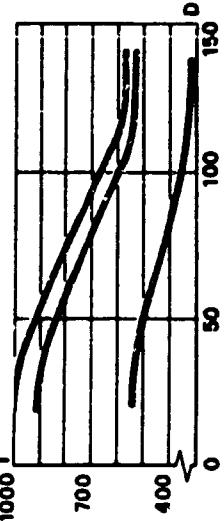
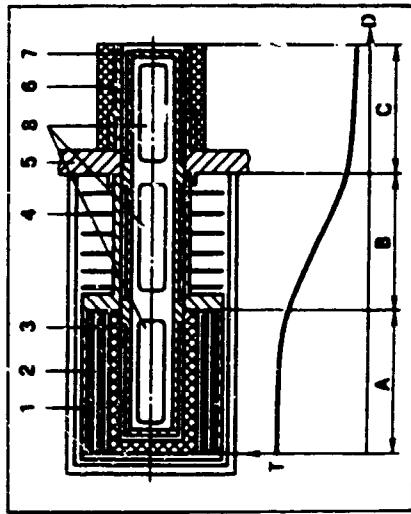
## BASIC SPECIFICATIONS OF THE SPLAV 02 UNIT

Spacecraft	Photon
Year of Introduction	1985
Mass, kg	120
Power Required, W	350
DIMENSIONS OF OBTAINED SAMPLE, mm:	
length	100
diameter	12
Number:	
of samples in a capsule	3
of capsules in the unit	12
Thermal Characteristics, °C	
heating temperature	400—1,070
specified temperature accuracy	±10
temperature maintenance accuracy	±3
Holding time at a given temperature, H	4.6, 9.2, 13.8, 18.2
Cooling rate, °C/h	2.8, 5.6, 11.3, 22.5
Temperature at the end of cooling, °C	300

Diagram of the electric heating chamber of Splav 02 and distribution of temperatures in the chamber.

1 - ruffle pipe; 2 - header; 3 - thermo-equalizer; 4 - screens; 5 - flange; 6 - casing; 7 - capsule; 8 - ampoule with materials. Zones: A - high-temperature, isothermal; B - transition; C - low-temperature, isothermal. T - temperature; D - dimensions, mm.

of samples in a capsule	3
of capsules in the unit	12
Thermal Characteristics, °C	
heating temperature	400—1,070
specified temperature accuracy	±10
temperature maintenance accuracy	±3
Holding time at a given temperature, H	4.6, 9.2, 13.8, 18.2
Cooling rate, °C/h	2.8, 5.6, 11.3, 22.5
Temperature at the end of cooling, °C	300



Conditions of carrying out experiments on the Splav 02 unit.

0-1 - heating; 1-2 - holding time; 2-3 - controllable cooling at the rate of S1; 3-4 - controllable cooling at the rate of S2; 4-5 - passive cooling

T - temperature; C - time.

TELEDYNE  
BROWN ENGINEERING  
1250 ACADEMY PARK LOOP  
(COLORADO SPRINGS, COLORADO 80910)

ORIGINAL PAGE IS  
OF POOR QUALITY

# KASHTAN SPECIFICATIONS

TE88910-518

## BASIC SPECIFICATIONS OF THE KASHTAN UNIT

Spacecraft.....	Photon
Mass, kg.....	60
Power Required, W.....	100
Electrode Voltage, V.....	500—5,000
Separation Chamber Length, mm.....	1,200
Cross-section of Separation Chamber mm <sup>2</sup> .....	5x5 or 10x5
Separation Chamber Capacity, ml.....	35 or 70
Single cell capacity, ml.....	0.7 or 1.4
Maximum Isolated Cells.....	49
Thermostatic Control Temperature, °C.....	5-25
Photographic Rate, Exposures/min.....	1

## SUMMARY

TS8810-819

- SOVIET MATERIALS SCIENCE PROGRAM IN SPACE CAN BE DIFFICULT TO ASSESS ACCURATELY DUE TO SYNTAX, INCONSISTENT DEFINITIONS, AND ERRORS IN SOVIET DOCUMENTS
- PROGRAM RETAINS HIGH PRIORITY AND IS CHARACTERIZED BY LARGE QUANTITY OF EXPERIMENTS ALTHOUGH DIVERSITY AND QUALITY SOMETIMES SUFFER
- EXPERIMENTS ON MIR ARE STILL RESTRICTED UNTIL DEDICATED MATERIALS PROCESSING MODULE ARRIVES - PROBABLY 1989
- MATERIALS SCIENCE EXPERIMENTS ON SOVIET SPACE STATIONS ACCOUNT FOR ONLY A SMALL PORTION OF CREW ACTIVITY
- UNMANNED MATERIALS PROCESSING SPACECRAFT (E.G. PHOTON) WILL CONTINUE DESPITE SPACE STATION ACTIVITIES

**TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP**  
**29 NOVEMBER 1988**

**MODULAR CONTAINERLESS PROCESSING FACILITY**  
**E.H. TRINH**  
**JET PROPULSION LABORATORY**

# MODULAR CONTAINERLESS PROCESSING FACILITY

## OUTLINE

- MCPF GENERAL DESCRIPTION
- PRIMARY FUNCTIONS
- RATIONALE FOR CONTAINERLESS EXPERIMENTS
- FACILITY EQUIPMENT
- RELEVANT SCIENTIFIC DISCIPLINES
- MCPF GENERIC EXPERIMENT TIMELINE
- CHAMBER PREPARATION / ENVIRONMENT CHARACTERIZATION
- SAMPLE PREPARATION / DEPLOYMENT
- ENVIRONMENT CONTROL ACTIVATION / SAMPLE PROCESSING / DATA ACQUISITION
- POST-PROCESSING FUNCTIONS
- CHAMBER PREPARATION / CHARACTERIZATION
- GENERAL CLOSING REMARKS

## MCPF GENERAL DESCRIPTION

### PRIMARY FUNCTIONS:

- TO PROVIDE THE
- CONTROLLED ENVIRONMENT
- SAMPLE HANDLING DEVICES
- DATA ACQUISITION, STORAGE AND TRANSFER DEVICES
- CREW AND GROUND CONTROL INTERFACES WITH THE PAYLOAD

NECESSARY FOR THE PERFORMANCE OF CONTAINERLESS SCIENTIFIC OR TECHNOLOGICAL EXPERIMENTS IN MATERIALS SCIENCE, FLUID PHYSICS, BIOTECHNOLOGY, AND EXOBIOLOGY IN MICROGRAVITY

## MCPF GENERAL DESCRIPTION

### RATIONALE FOR CONTAINERLESS EXPERIMENTS IN MICROGRAVITY

- USE OF LOW MAGNITUDE POSITIONING FORCES POSSIBLE
- STUDY OF SMALL MAGNITUDE CAPILLARY PHENOMENA ON FREE LIQUID SURFACES
- POTENTIAL FOR PROCESSING OF HIGH PURITY MATERIALS
- POTENTIAL FOR PROCESSING HIGH TEMPERATURE AND HIGHLY REACTIVE MATERIALS
- POSSIBILITY FOR NON-CONTACT SHAPING OF MELTS AND MANUFACTURE OF APPLICATION-READY PARTS
- OPPORTUNITY TO DEVELOP NON-CONTACTING DIAGNOSTIC TECHNIQUES TO REFINE GROUND-BASED TECHNOLOGY
- SPACE STATION OPPORTUNITY: LONG DURATION, MANY REPETITIVE CYCLES EXPERIMENTS

## MCPF GENERAL DESCRIPTION

### MULTI-MODULE FACILITY:

- HIGH TEMPERATURE ACOUSTIC POSITIONER
- HIGH TEMPERATURE ELECTROMAGNETIC POSITIONER
- ELECTROSTATIC-ACOUSTIC HYBRID POSITIONER
- GAS-GRAIN MODULE (\*)

### PRECURSOR FLIGHT HARDWARE :

- 3 AAL (61C)
- ACES (41C)
- DDM (51B)
- EML (61C)
- SAAL (DLM)

SHUTTLE/SPACELAB PREVIOUSLY FLOWN EQUIPMENT

### FUTURE EQUIPMENT FOR USML / IML SPACELAB FLIGHTS:

- DROP PHYSICS MODULE (DPM, CODE EN)
- ACOUSTIC LEVITATION FURNACE (ALF, CODE EN)
- MODULAR ELECTROMAGNETIC LEVITATOR (MEL, CODE EN)
- TEMPUS (ESA) (\*)

D.F.V.R.

EHT 11/88 JPL

## MCPF GENERAL DESCRIPTION

### SCIENTIFIC DISCIPLINES SERVED:

- GLASSES AND CERAMICS: CRYSTAL NUCLEATION, GLASSIFICATION, PHASE TRANSFORMATION AND SEPARATION, ULTRA-HIGH TEMPERATURE GLASSES PROPERTIES, SPECIA' PROPERTY GLASSES AND CERAMICS
- METALS AND ALLOYS: NUCLEATION STUDIES, METASTABLE STRUCTURES, HIGH TEMPERATURE PROCESSING AND PROPERTIES, HIGH PURITY, CONTROLLED REACTIONS EXPERIMENTS
- ELECTRONIC MATERIALS: HIGH TEMPERATURE MELT PROPERTIES
- FLUID PHYSICS: FREE LIQUID SURFACE BEHAVIOR, THERMO-CAPILLARY PHENOMENA, NONLINEAR DYNAMICS, TURBULENCE, GEOPHYSICAL MODELLING
- BIOTECHNOLOGY: CONTAINERLESS PROTEIN CRYSTAL GROWTH, POLYMERIZATION STUDIES
- EXOBIOLOGY: METEORITICS MODELLING, PLANETARY ATMOSPHERES NUCLEATION STUDIES

**MCPF GENERIC EXPERIMENT TIMELINE**

- A. CHAMBER PREPARATION / ENVIRONMENT CHARACTERIZATION**
- B. SAMPLE PREPARATION / DEPLOYMENT**
- C. ENVIRONMENT CONTROL ACTIVATION / SAMPLE PROCESSING / DATA ACQUISITION**
- D. EXPERIMENT REPETITION**
- E. POST-PROCESSING SAMPLE RETRIEVAL / CHARACTERIZATION / STORAGE**
- F. CHAMBER PREPARATION / PURIFICATION / CHARACTERIZATION**

## MCPF GENERIC EXPERIMENT TIMELINE

### A. CHAMBER PREPARATION / ENVIRONMENT CHARACTERIZATION

- HIGH VACUUM ..... (VENTING)
- VACUUM BAKEOUT .....(GAS TRAPPING, POWER)
- INERT GAS BACKFILL (1 BAR OR >1 BAR)----(HIGH PURITY GAS SUPPLY AND MONITORING)
- PARTICULATE CONTAMINATION MONITORING AND CONTROL .....  
(DIAGNOSTIC INSTRUMENTATION)

MCPF GENERIC EXPERIMENT TIMELINE

**B. SAMPLE PREPARATION / DEPLOYMENT**

- NO PREPARATION (SAMPLE DIRECTLY DEPLOYED BY MCPF DEVICE)
- SAMPLE CHARACTERIZATION (PREPARATION REQUIRED IN MANNED ENVIRONMENT) ----- (MATERIALS SCIENCE GLOVEBOX, SAMPLE TRANSPORT AND HANDLING PROCEDURES, CREW)
- SAMPLE IS PREPARED PRIOR/ AFTER CHAMBER PREPARATION
- SAMPLE SIZES : 500 MICRONS TO 2 CM
- SAMPLE NUMBER: SINGLE, MULTIPLE, OR SAMPLE SWARM (LESS THAN 500 MICRONS SIZE)
- SAMPLE STATE: LIQUID OR SOLID, GASES ALSO DEPLOYED
- SAMPLE DEPLOYMENT ( INSERTION INTO CHAMBER ) ----- (CREW)

## MCPF GENERIC EXPERIMENT TIMELINE

### C. SAMPLE PROCESSING

- ENVIRONMENT CONTROL ACTIVATION ..... ( FURNACE POWER, THERMAL OVERLOAD CONTROLS, STATIC PRESSURE CONTROL, GAS COMPOSITION MONITORING, PARTICULATE CONTAMINATION MONITORING)
- FACILITY DIAGNOSTICS ACTIVATION ..... (DATA ACQUISITION, STORAGE AND DOWNLINK)
- SAMPLE MANIPULATION (MELTING, SUPERHEATING, ROTATION, OSCILLATION, ETC...) ..... (SAMPLE OBSERVATION / DOWNLINK)
- PROPERTIES MEASUREMENT ..... (DATA ACQUISITION, STORAGE, AND DOWNLINK)
- RADIANT (BEAM) HEATING ACTIVATED ..... (BEAM POWER, SAFETY CONTROLS)
- SAMPLE SOLIDIFICATION ..... (HEAT REMOVAL)
- END OF EXPERIMENT (SAMPLE RETRIEVAL OR EXPERIMENT REPEAT)
- FLUID REMOVAL AND TRAPPING (GASES AND LIQUIDS) ....(PMMS)

MCPPF GENERIC EXPERIMENT TIMELINE

D. EXPERIMENT REPETITION

. MULTI-CYCLE RUNS ----- (POWER, PMMS)

**MCPF GENERIC EXPERIMENT TIMELINE**

**E. POST-PROCESSING SAMPLE RETRIEVAL / CHARACTERIZATION / STORAGE**

- . SAMPLE RETRIEVAL (LIQUID, SOLIDS, SUSPENSION)----- (SAMPLE HANDLING, CREW)**
- . SAMPLE NOT ANALYZED ----- (STORAGE IN MCPF OR IN USL FACILITY)**
- . SAMPLE CHARACTERIZATION (SEM, ETCHING, MICROSCOPY,...)--- USL COMMON FACILITIES, CREW**

## MCPF GENERIC EXPERIMENT TIMELINE

### F. CHAMBER PREPARATION / PURIFICATION / CHARACTERIZATION

- ANALYSIS OF ENVIRONMENT PRIOR TO SAMPLE REMOVAL ----- (MCPF OR USL DIAGNOSTICS)
- CHAMBER EVACUATED ----- (VENTING, GAS TRAPPING)
- CHAMBER PURIFIED (BAKEOUT OR PURGING) ----- (POWER, VENTING)
- CHAMBER CHARACTERIZATION

## Modular Containerless Processing Facility

### MCPF EXPERIMENTS NOT YET DEFINED

- Experiments & Principal Investigators are selected by orderly process
- Selection based upon responses to NASA Announcement of Opportunity (AO)
- MCPF work now based upon capabilities
  - Capabilities include most known candidate experiments

## **Modular Containerless Processing Facility**

### **MCPF Conducts Multiple Experiments**

- Baseline configuration has three (3) experiment modules at PMC
- Experiment modules may have multiple chambers
  - Additional experiments may be added
- Simple and small experiments not in reference set
- Quick-is-Beautiful class to be defined later
- Get Away Special class
- Commercial experiments that can use the facility
- MCPF engineering development
- Any other relevant experiments that make good use of facility
- Experiments can run concurrently

## Modular Containerless Processing Facility

- MCPF Experiments Change
- MCPF is Modular so it can change on orbit

### MCPF is Evolutionary

- MTC Phase Experiments
  - Remote and automatic without crew
  - Power to fit what's available
  - Data to fit capability
- Early PMC
  - Start Experiment changeout
  - New Experiment every 90 days
- PMC + 1 year
  - Changeout of experiments complete
  - This is the MCPF version described at Payload Accommodations Workshop
    - Huntsville, Jan 1988

## Modular Containerless Processing Facility

— 2 —

### FLEXIBILITY

- Not just a manifestation of uncertainty
- Its a requirement

### NEED

- An orderly process
- Face-to-face contact with Work Package contractors
  - Who are they?
  - When do they need what?
- Plan
  - AO is major milestone
    - When is AO needed to match Work Package needs?

## **11. SPACE STATION FURNACE FACILITY**

**NOTE: No hardcopy of this presentation was provided for the Workshop Proceedings.**

SPACE STATION  
TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP  
HUNTSVILLE, ALABAMA  
NOV 29, 30 & DEC 1, 1988

OVERVIEW  
OF  
MODULAR COMBUSTION FACILITY



LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

ENGINEERING DIRECTORATE P.M.	RON CHUCKSA
SPACE EXPERIMENTS DIV P.M.	BOB THOMPSON
FACILITY PROJECT SCIENTIST	KURT SACKSTEINER
STUDY TEAM MEMBER (PMMS)	DON PERDUE

NASA  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

## MODULAR COMBUSTION FACILITY

OBJECTIVE, DEVELOP A MODULAR, MULTIUSER MICROGRAVITY SCIENCE FACILITY FOR USE BY THE COMBUSTION SCIENCE COMMUNITY ON BOARD THE SPACE STATION FREEDOM LABORATORY

CURRENT EFFORT, DEFINITION STUDY & CONCEPTUAL DESIGN

APPROACH,

- START WITH A REPRESENTATIVE LIST OF POTENTIAL MICROGRAVITY SCIENCE EXPERIMENTS FOR COMBUSTION OVER A BROAD RANGE OF CONDITIONS/REQUIREMENTS
- WORK WITH REPRESENTATIVES OF EACH OF THESE POTENTIAL EXPERIMENTS TO DETERMINE REQUIREMENTS
- GENERATE PRELIMINARY CONCEPTUAL SCHEMATIC DIAGRAM FOR EACH POTENTIAL EXPERIMENT AS IT MIGHT EXIST IN THE USL ENVIRONMENT
- GENERATE A DATABASE OF EXPERIMENTAL REQUIREMENTS
- EXTRACT COMMON SYSTEMS TO FORM THE BASIS FOR A HOST FACILITY
- MERGE COMMON SYSTEMS REQUIREMENTS WITH KNOWN SPACE STATION REQUIREMENTS/CAPABILITIES TO FORM A HOST FACILITY



LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

MODULAR COMBUSTION FACILITY (MCF)  
REFERENCE EXPERIMENT SETS

- [C01] GASEOUS FUEL COMBUSTION STOCKER - LaRC
- [C02] FLAMING AND SMULDERING COMBUSTION IN LOW VELOCITY FLOWS OLSON - LaRC  
FREIDMAN - LaRC  
SACKSTEDER - LaRC
- [C03] POOL FIRES ROSS - LaRC
- [C04] EFFECTIVENESS OF CANDIDATE EXTINGUISHANTS FOR USE ON SMULDERING OR FLAMING COMBUSTION IN LOW GRAVITY FREIDMAN - LaRC
- [C05] DROPLETS COMBUSTION SACKSTEDER - LaRC
- [C07] METALS COMBUSTION BENZ - WHITE SANDS

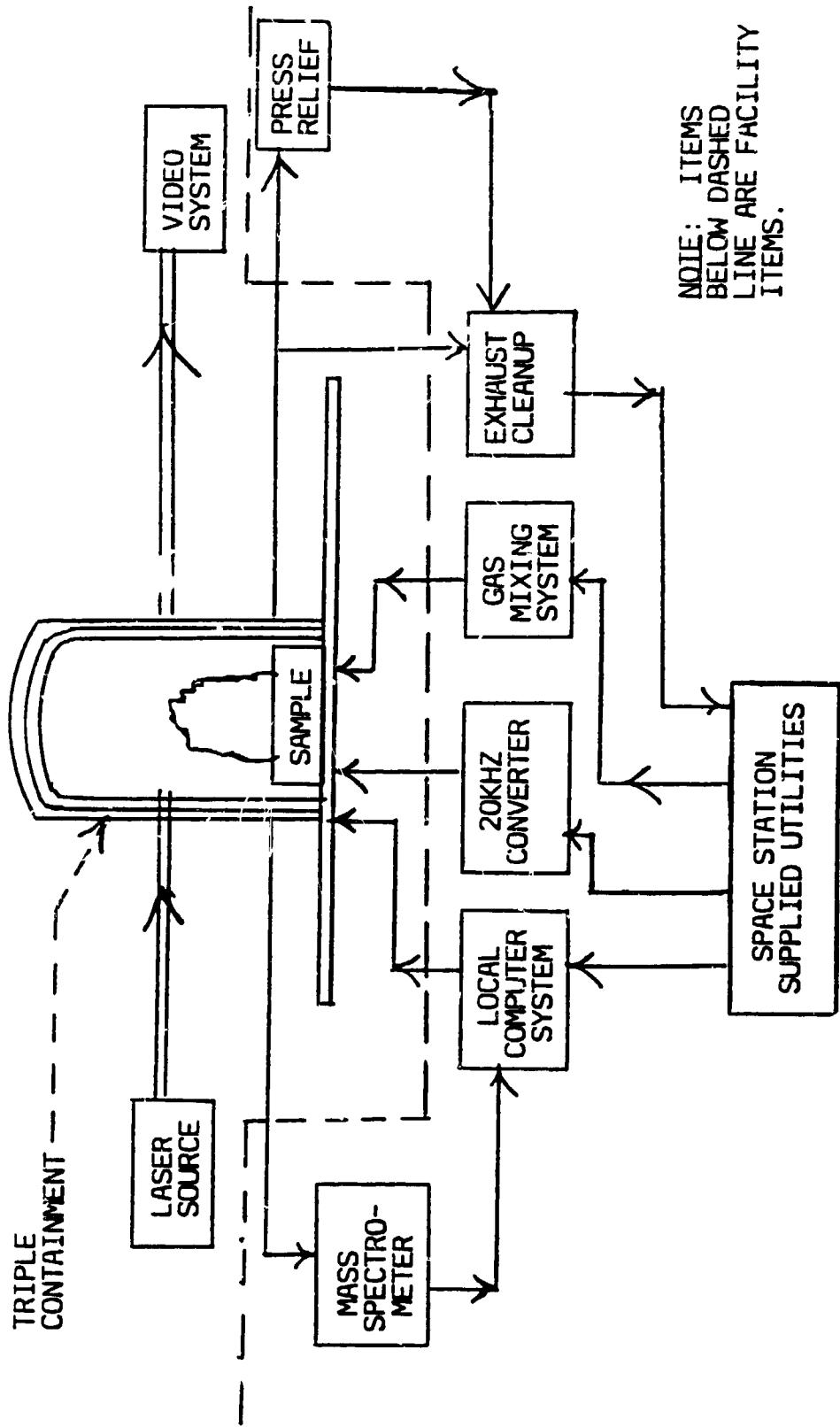
REVISED 11 APR 84



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

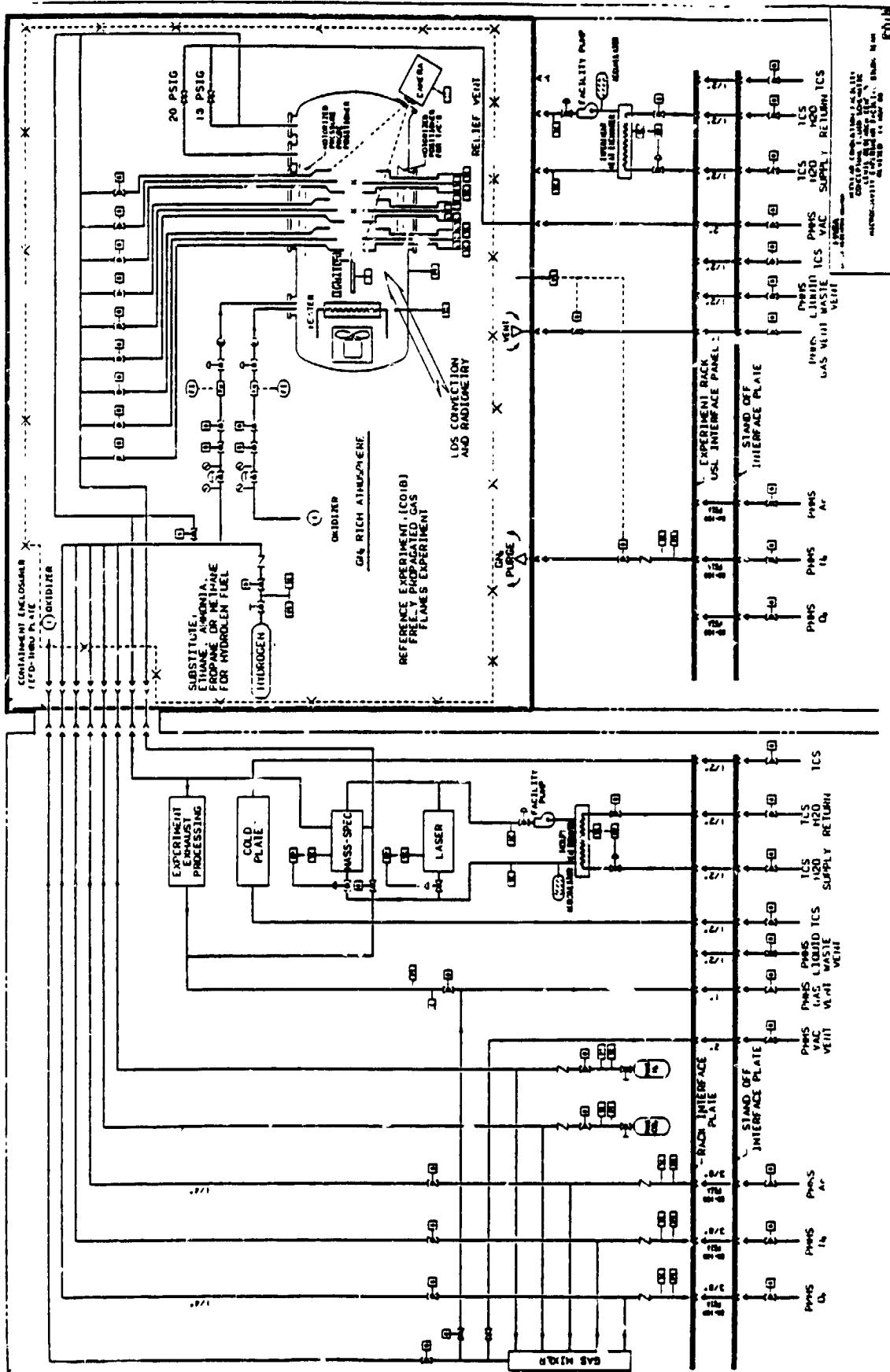
LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

BLOCK DIAGRAM FOR TYPICAL COMBUSTION EXPERIMENT



פָּרָשָׁת  
בְּנֵי  
יִשְׂרָאֵל

EXPOSITION FRAN



# MODULAR COMBUSTION FACILITY

## EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

### SECTION 1.1: GENERAL INFORMATION

EXPERIMENT	SOURCE OF REQUIREMENTS				
NAME	S	R	CONTACT		
(NO.)	/ UPDATED	C	PHONE NUMBER	ORGANIZATION	EXPERIMENT DESCRIPTION

### SECTION 1.2: GENERAL INFORMATION

EXPERIMENT	TOTAL	SETUP	PRE-TEST	TEST	POST-TEST	SHUTDOWN
NAME	S	R	% CREW	TIME	% CREW	TIME
(NO.)	OF RUNS	TIME	% CREW	TIME	REQ'D	REQ'D

### SECTION 1.3: GENERAL INFORMATION

EXPERIMENT	ITEMS IN CURRENT CEI SPEC		ITEMS NOT IN CURRENT CEI SPEC	
NAME	S	R	S	R
(NO.)	/ UPDATED	C	LAB SUPPORT EQUIPMENT ITEM TITLE	ND

### 2.1: ELECTRIC POWER DISTRIBUTION

EXPERIMENT	VOLTAGE	FREQUENCY	NUMBER OF PHASES	PEAK POWER (watts)	DUTY CYCLE	AVE. POWER (watts)	COMMENTS
NAME	(volts)	(hertz)	PHASES	(watts)	(watts)	(watts)	
(NO.)	/ UPDATED	C	SUBSYSTEM	LOAD DESCRIPTION			



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

# MODULAR COMBUSTION FACILITY

## EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

### SECTION 3.1 - TRANSMIERS & SIGNAL CONDITIONERS

EXPERIMENT	NO.	NO.	IC	TRANSDUCER	SIGNAL CONDITIONER	ON-BOARD
NAME	S	GENERIC	CHAN			
(NO.)	R	MEASUREMENT	PER			
/UPDATED	C	TYPE	TYPE			

### SECTION 3.2: VIDEO SYSTEMS

EXPERIMENT	VIDEO	IN	IC	STORED	DATA	ON-BOARD
NAME	U	1	0	CAMERA		
(NO.)	R	D	1	GRAY		
/UPDATED	C	S170	0	STAT.		
				FRAME		
				RES.		
				FRAMES		
				EQ.		

### SECTION 3.3 - FILM CAMERA SYSTEMS

EXPERIMENT	FORMAT	COLOR	FIXED	DEPTH	FILE	FRAMES	AMBIENT	NO.	DATA
NAME	OF	C2E	OR	OF	PER	OR	SPECTRAL	VIEWS	ANNO-
(NO.)	CAH-	35mm-STILL	BEW	FIELD	VIEW	PER	RESPONSE	PER	ATION
/UPDATED	ERAS	70mm-STILL	HELD		RUN			CAMERA	REQ'D
									(Y/N)

### SECTION 3.4 - DATA ACQUISITION

EXPERIMENT	ANALOG	DIGITAL	SERIAL	SAMPLES	DATA RATE	MASS	VIDEO	DATA	HIGH
NAME	LINEs	LINEs	LINEs	LINEs	BITS PER	STORAGE	ENCYP-	RATE	
(NO.)	S	IN	001	IN	OUT	SECOND		PER	D-7A
/UPDATED	R					(AS232)			LINE
	C					ETC.)	(MAX)	(PER RUN)	

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM  
CLEVELAND, OHIO

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

# MODULAR COMBUSTION FACILITY

## EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

### SECTION 3.5: LASER DIAGNOSTIC SYSTEMS/OPTICAL MEASUREMENTS

EXPERIMENT NAME (NO.)	GENERIC MEASUREMENT TYPE	PRO- FILE	SPATIAL RES.	TIME	RESOLU- TION	SUITABLE DATA	TECHNIQUES	DEVELOPMENT RATE	ISSUES	DATA PROCESS.	POWER NOMINAL/	OUTPUT
R/UPDATED /C	RANGE	ANCE	POINT	ION	DATA	TECHNIQUES	DEVELOPMENT	PEAK	REAL	FORMAT	TIME OR DEFERRED	DISPLAY
	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK

### SECTION 4: ELECTRIC CONTROLS

EXPERIMENT NAME (NO.)	CONTROLLED DEVICE OR SUBSYSTEM	CONTROL SIGNALS	REQUIRED FAILURE MISSION CRITICAL LOOP	FAILURE SAFETY CRITICAL TOLE	TOLERANCE LEVEL	ALL SUB- SYSTEM REQUIRE- MENTS
R/UPDATED /C	DIS- CRETE TITLE	ANALOG CREATE VALUE	S/W OR TIME	(YES-NO)	(0, 1 OR 2)	HE1
			XDCR			

### SECTION 5.1 - CONSUMABLES

EXPERIMENT NAME (NO.)	MATERIAL NAME AND FORMULA	GAS LIQUID SOLID OR OTHER	NUMBER OF RUNS PER 90 DAYS (min/max)	MASS RUN DURATION (minutes)	MASS FLOW	VOLUME FLOW	MASS CONSUMED/	MASS SUPPLIED	TEST CHAMBER PRESSURE	TEST CHAMBER TEMP

### SECTION 5.2: WASTE DISPOSAL

EXPERIMENT NAME (NO.)	MATERIAL NAME AND FORMULA	VAPOR MASS PER RUN (kg)	LIQUID MASS PER RUN (kg)	SOLID MASS PER RUN (kg)	PARTICULAT SIZE (microns)	TOTAL MASS PER 90-DAYS (kg)	RISK ASSESS- MENT	TEMP. OF WASTE (K)	PRESS. OF WASTE (Kpa)	HAZARD LEVEL



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO



# MODULAR COMBUSTION FACILITY

## EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

SECTION 5.2. VENTING

## SECTION 5.4: THERMAL COOKING

EXPERIMENT NAME (NO.1)	HEAT LOAD PER RUN	TEMPER- ATURE RANGE	COOLING METHOD			VOLUME FLOW OF FLUID	MINIMUM COOLANT TEMP. (K)	COOLANT FLUID PRESSURE (kPa)	COMMENTS
			AVIONICS	AIR	Liquid/ GAS COOLPLATE COOLED COOLED				
1/0-DATED	(C)	(K)							

## SECTION 6.1: TEST SECTION



# NATIONAL AERONAUTICS & SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CUYAHOGA FALLS, OHIO

# MODULAR COMBUSTION FACILITY

## EXPERIMENTAL REQUIREMENTS DATABASE FORMATS

### SECTION 6.2: ITEMS OTHER THAN TEST SECTION

EXPERIMENT	ITEMS TO BE INCLUDED IN EXPERIMENTAL	DIMENSIONS	VOLUME	MASS	COMMENTS
NAME (NO.)		WIDTH [LENGTH] DEPTH	(cubic meters)	(kg)	

### SECTION 6.3 - ADDITIONAL EXPERIMENT PECULIAR STRUCTURAL REQUIREMENTS IN RACK

EXPERIMENT	VIBRATION	EMC (ELECTROSTATIC CONTROL)	THERMAL INSULATION	CONTAINMENT REQUIRED FOR SAFETY	OTHERS
NAME (NO.)	ISOLATION				

### SECTION 7.1: ACCELERATION

EXPERIMENT	SUSTAINED ACCELERATION	TRANSIENT	ALIGNMENT REQUIREMENTS	COMMENTS
NAME (NO.)	DIRECTION	g/s	hz	duration g -sec



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## MODULAR COMBUSTION FACILITY

### PRESENT FACILITY CONCEPTS

- MODULAR CONCEPT
- TWO RACK FACILITY
  - PERMANENT FACILITY RACK
  - INTERCHANGEABLE EXPERIMENT RACK
- FACILITY RACK
  - INTERFACE BETWEEN USL & EXPERIMENT
  - HOUSES SUPPORT SYSTEMS
  - POWER CONVERSION & DISTRIBUTION SYSTEM
  - DATA ACQUISITION & CONTROL COMPUTER SYSTEM
  - GAS MIXING & DISTRIBUTION SYSTEM
  - EXPERIMENTAL BY-PRODUCTS CONDITIONING SYSTEM
  - LASER DIAGNOSTIC SUPPORT SYSTEM
  - HIGH RESOLUTION HIGH FRAME RATE VIDEO SUPPORT SYSTEM
  - MASS SPECTROMETER
  - SAFETY SYSTEMS
  - OPERATOR INTERFACE PANEL
- EXPERIMENT RACK
  - RACK INTEGRATED ON GROUND
  - POSSIBLE CHANGE-OUT EVERY 12 TO 18 MONTHS
  - HOUSES CONTAINMENT ENCLOSURE
  - VARIOUS EXPERIMENT MODULES
    - COMBUSTION CHAMBER
    - VERY LOW SPEED COMBUSTION TUNNEL

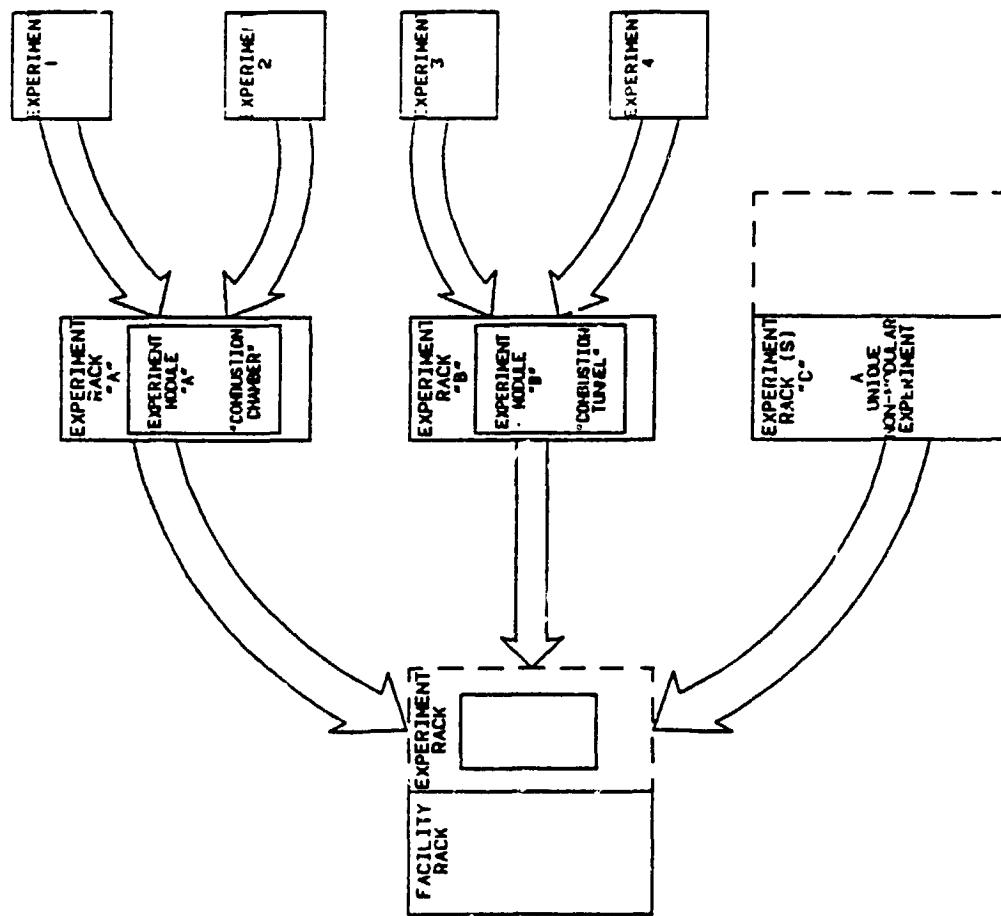


MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

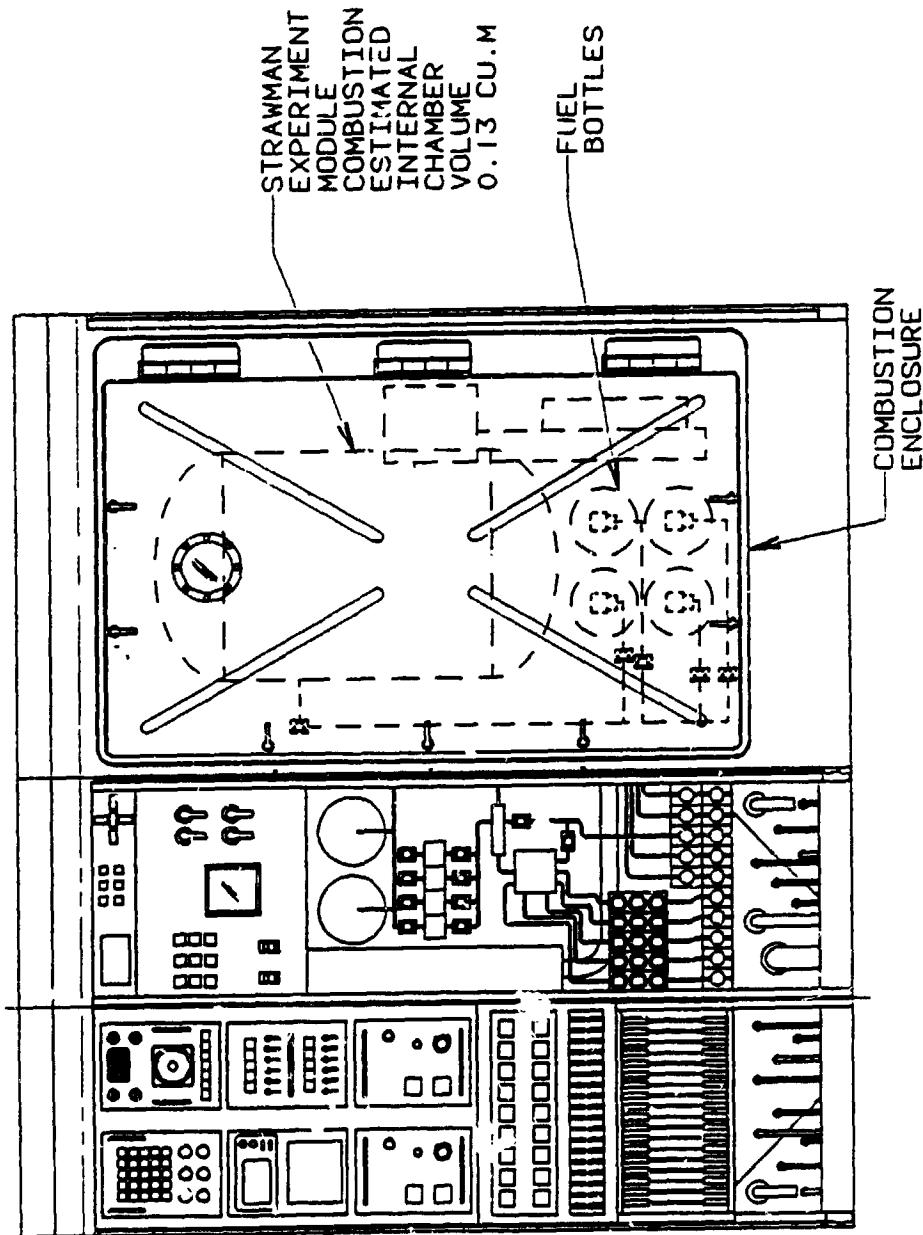
Lewis Research Center  
CLEVELAND, OHIO

# MODULAR COMBUSTION FACILITY

## MODULAR CONCEPT

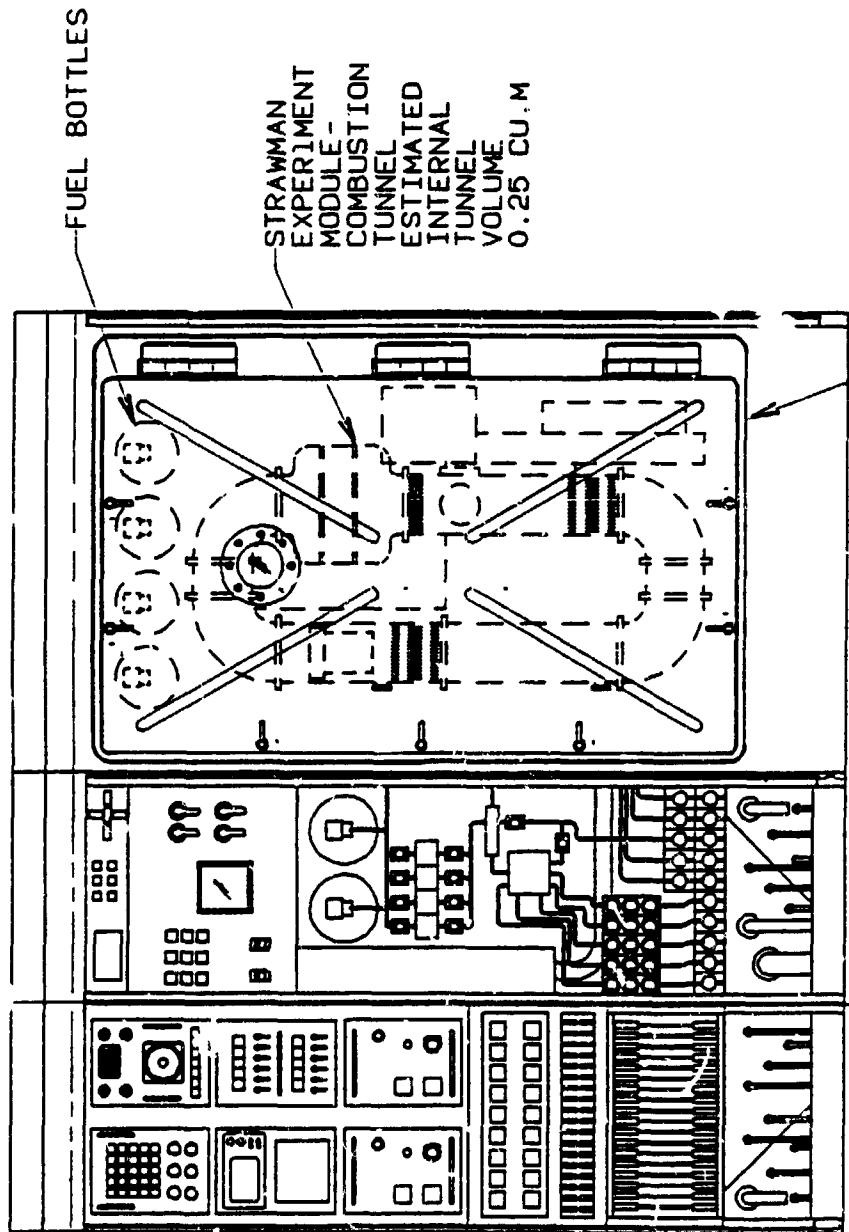


MODULAR COMBUSTION FACILITY  
(SHOWN WITH STRAWMAN EXPERIMENT MODULE INSTALLED)



MODULAR COMBUSTION FACILITY

(SHOWN WITH LOW-SPEED COMBUSTION TUNNEL EXPERIMENT MODULE INSTALLED)

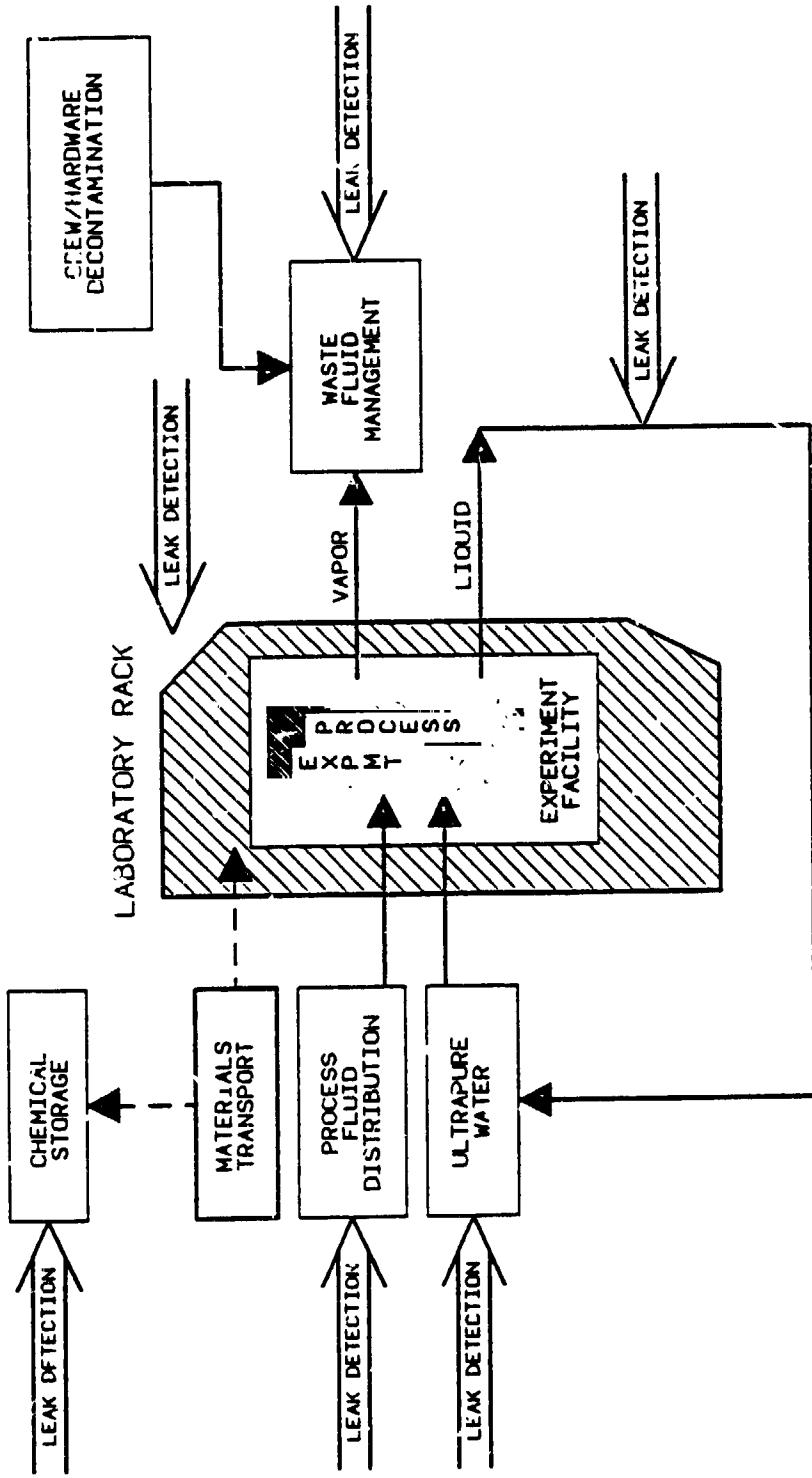


**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

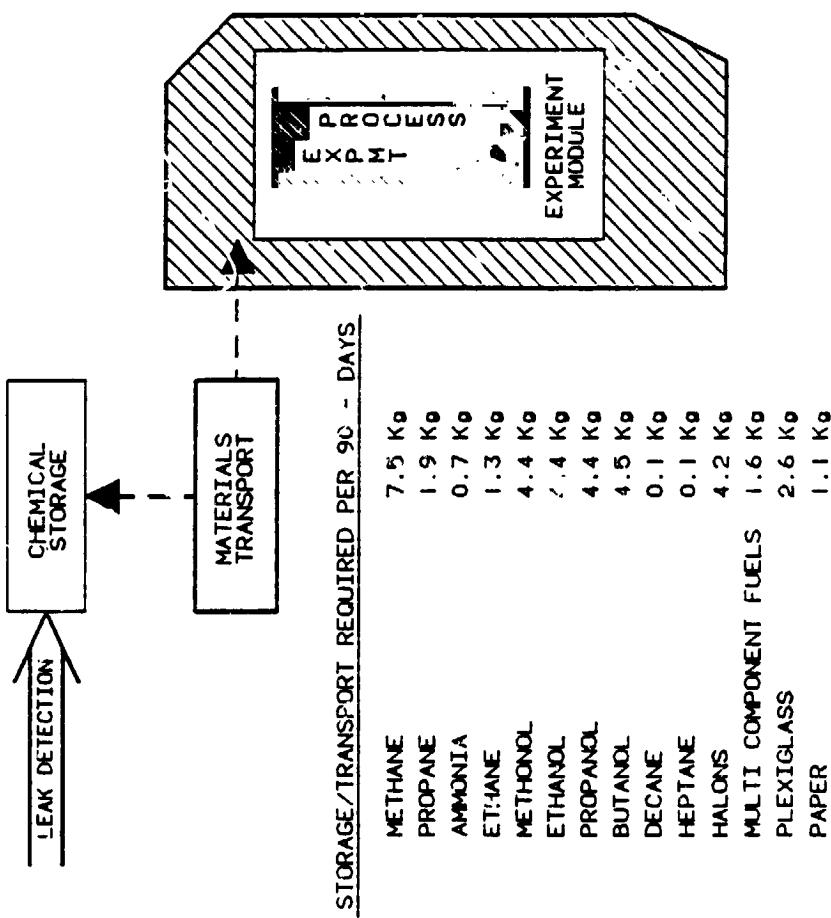
LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

U.S. LABORATORY REVIEW WORKSHOP  
 (HUNTSVILLE - AUGUST 1988)  
 PMMS FUNCTIONAL DIAGRAM



MODULAR COMBUSTION FACILITY  
CHEMICAL STORAGE & MATERIALS TRANSPORTS USAGES

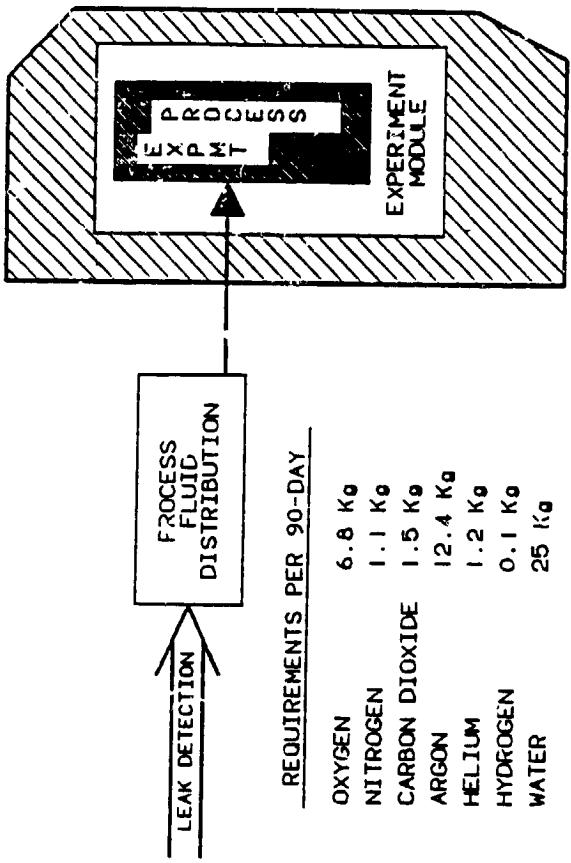


**NASA**  
 NATIONAL AERONAUTICS &  
 SPACE ADMINISTRATION

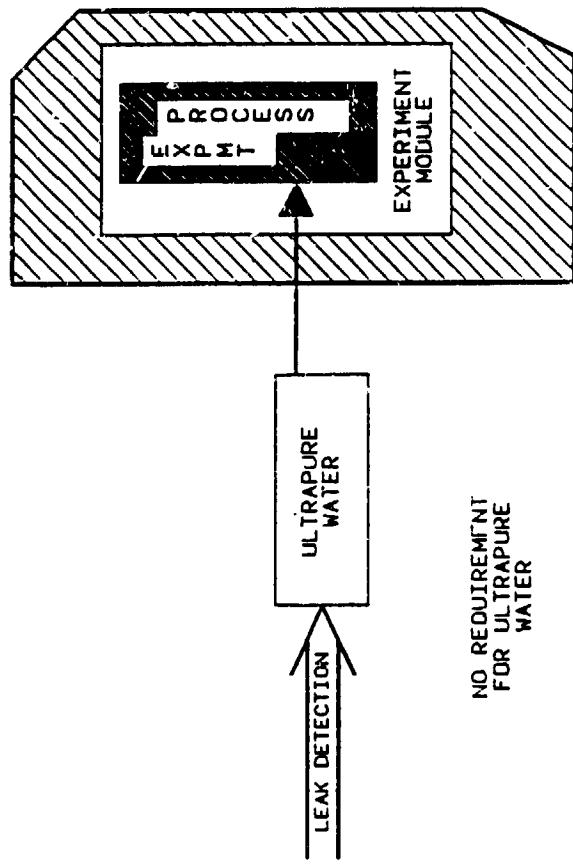
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
 CLEVELAND, OHIO

MODULAR COMBUSTION FACILITY  
USL SUPPLIED CONSUMMABLES USAGE

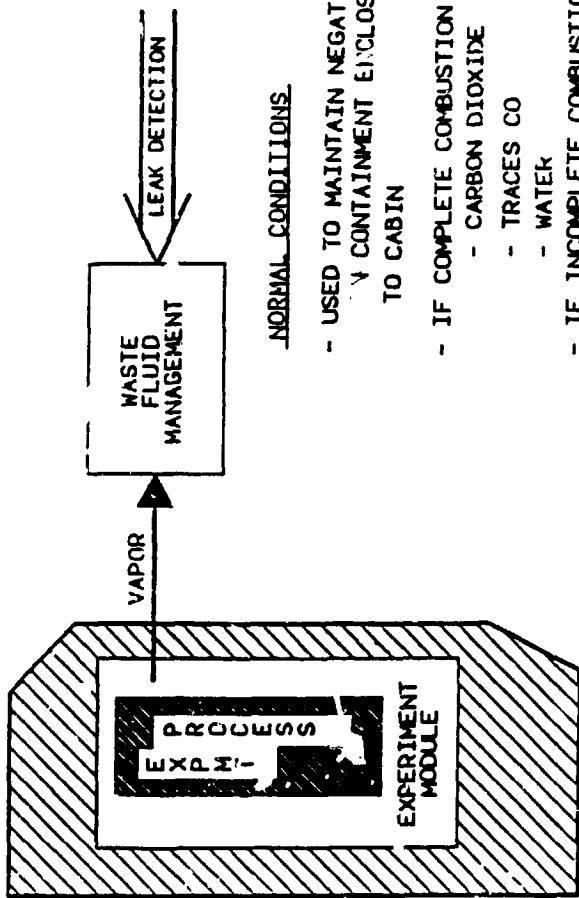


MODULAR COMBUSTION FACILITY  
ULTRAPURE WATER USAGE



## MODULAR COMBUSTION FACILITY

### WASTE FLUIDS MANAGEMENT USAGE



#### NORMAL CONDITIONS

- USED TO MAINTAIN NEGATIVE PRESSURE  
IN CONTAINMENT ENCLOSURE RELATIVE  
TO CABIN
- IF COMPLETE COMBUSTION GET:
  - CARBON DIOXIDE
  - TRACES CO
  - WATER
- IF INCOMPLETE COMBUSTION GET:
  - UNBURNED FUEL - (PROPANE, METHANE, ETC.)
  - SMALL PERCENT CO<sub>2</sub>, CO & WATER
  - SOOT (CARBON)
- IN EITHER CASE
  - COULD GET EXTINGUISHANTS ADDED
  - HALONS
  - WATER
  - CO<sub>2</sub>
  - TOXICS FORMED
- IF TEMPERATURE HIGH ENOUGH
  - NITROGEN & SULFUR COMPOUNDS
- ADDITIONAL STUDY REQD

#### ABNORMAL CONDITIONS - (EXAMPLE - NO IGNITION)

- UNBURNED FUELS - (PROPANE, METHANE, ETC.)

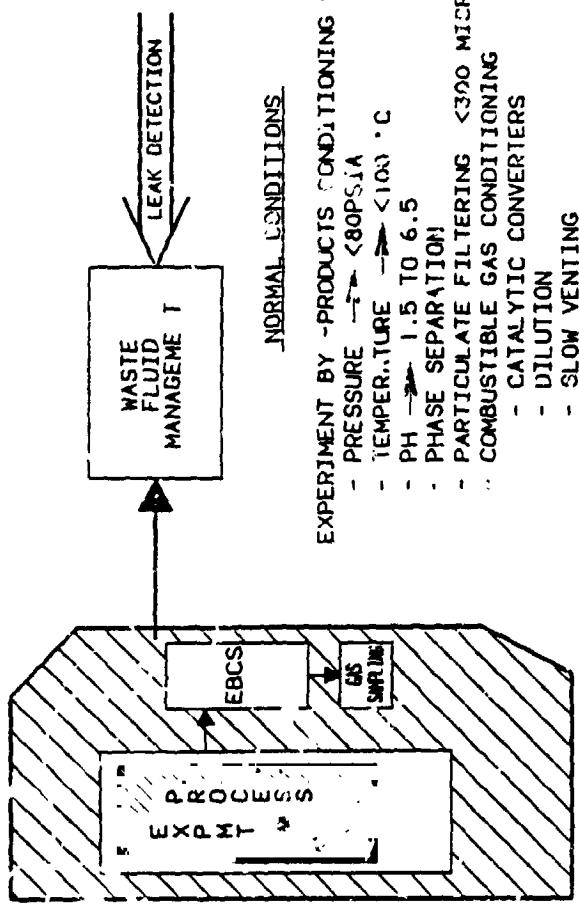
LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

## MODULAR COMBUSTION FACILITY

### CONCEPT DESIGN



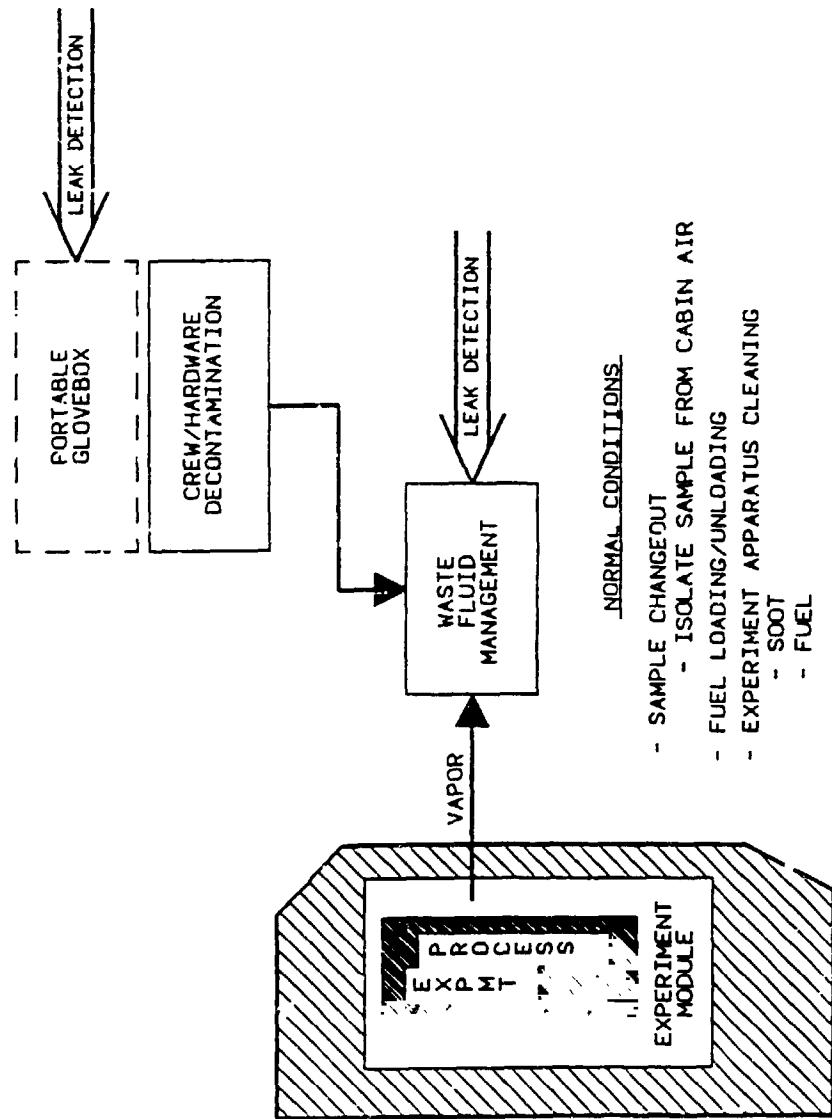
**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## MODULAR COMBUSTION FACILITY

### "PORTABLE GLOVEBOX USES"



#### NORMAL CONDITIONS

- SAMPLE CHANGEOUT
- ISOLATE SAMPLE FROM CABIN AIR
- FUEL LOADING/UNLOADING
- EXPERIMENT APPARATUS CLEANING
- SOOT
- FUEL

#### ABNORMAL CONDITIONS

- MAJOR CLEANUP
- POSSIBLE APPARATUS CHANGEOUT



NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

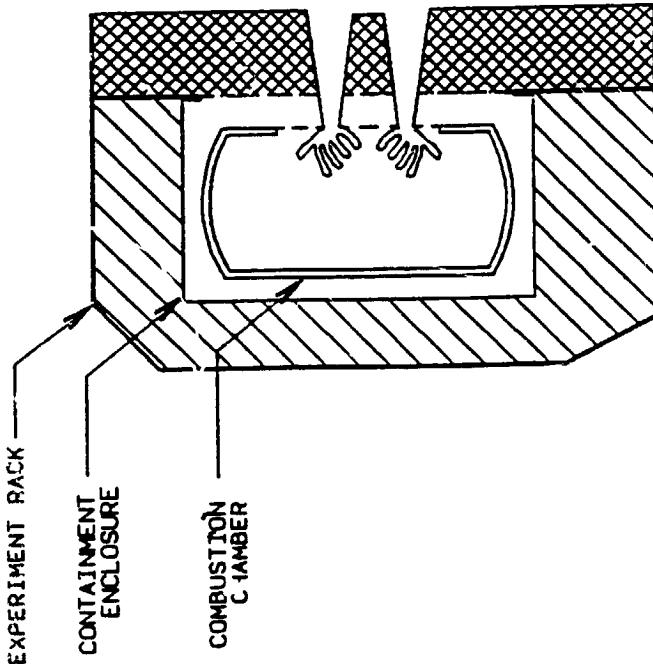
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

Lewis Research Center  
Cleveland, Ohio

## MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT I FIXED FORM STANDARD ATTACHMENT TO ENTIRE RACK



### POSITIVE FEATURES

- STANDARD INTERFACE TO ALL RACKS

### NEGATIVE FEATURES

- DOES NOT ISOLATE CONTAINMENT ENCLOSURE FROM REST OF RACK
- DIFFICULT PROBLEM WITH CONTAINMENT ENCLOSURE & CHAMBER ACCESS DOOR
- MAY BE UNABLE TO REACH ALL PARTS OF CHAMBER

### POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX
- ADAPTERS

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

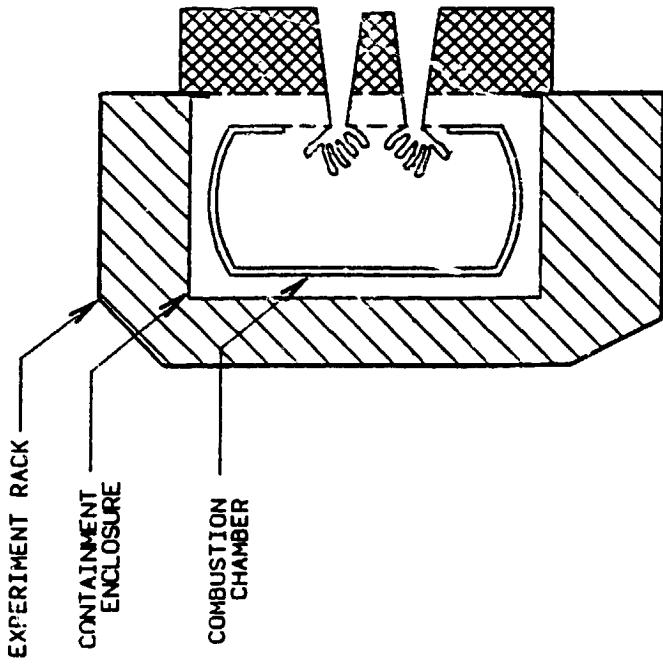
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT II FIXED FORM ATTACHMENT TO USER'S CONTAINMENT ENCLOSURE



### POSITIVE FEATURES

### FLAT FIXED ATTACHMENT SURFACE

### NEGATIVE FEATURES

- DOES NOT ISOLATE CONTAINMENT ENCLOSURE FROM CHAMBER
- DIFFICULT PROBLEM WITH CONTAINMENT ENCLOSURE & CHAMBER ACCESS DOORS
- MAY BE UNABLE TO REACH ALL PARTS OF CHAMBER

### POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX
- ADAPTER

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

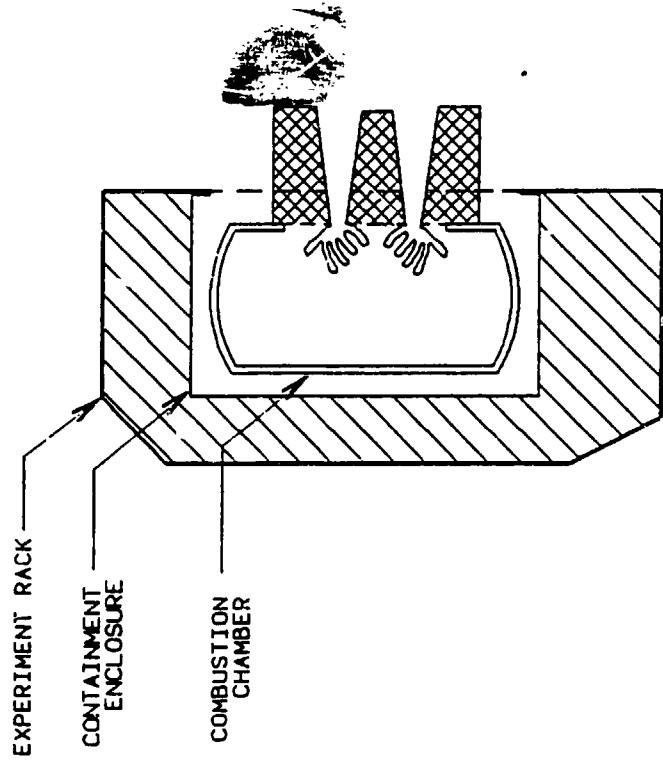
MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## MODULAR COMBUSTION FACILITY

(EARLY CONCEPTS FOR PORTABLE GLOVEBOX USES)

CONCEPT III: FIXED FORM ATTACHMENT TO USER'S CHAMBER



### POSITIVE FEATURES

- SMALLER
- ISOLATES CHAMBER

### NEGATIVE FEATURES

- ROUND VARIABLE ATTACHMENT SURFACE
- DIFFICULT PROBLEM WITH CHAMBER ACCESS DOOR
- BETTER- BUT REACHING BACK OF CHAMBER MAY BE A PROBLEM

### POSSIBLE STUDY AREAS

- FREE FORM GLOVEBOX
- DISPOSAL GLOVEBOX

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## MODULAR COMBUSTION FACILITY

### ISSUES AND CONCERNS

- MULTI-RACK FACILITY - INTER-RACK CONNECTIONS
- CONTAINMENT
- PMMS AVAILABILITY
- USL SUPPLIED FLUIDS
- EMERGENCY/CREW RESPONSE, ETC.
- PORTABLE GLOVEBOX
- USER INTERFACE WITH WP-01
- TECHNOLOGY DEVELOPMENT OF SYSTEMS
- COMPATIBILITY WITH JEM, COLUMBUS & CDSF



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

SPACE STATION  
TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP  
HUNTSVILLE, ALABAMA  
NOV 29, 30 & DEC 1, 1988

OVERVIEW  
OF  
FLUID PHYSICS/DYNAMICS FACILITY



LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

ENGINEERING DIRECTORATE P.M. | RON CHUCKSA  
SPACE EXPERIMENTS DIV P.M. | BOB THOMPSON  
FACILITY PROJECT SCIENTIST | JACK SALZMAN  
STUDY TEAM MEMBER (PMSS) | DON PERDUE

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

## FLUID PHYSICS/DYNAMICS FACILITY

**OBJECTIVE:** DEVELOP A MODULAR, MULTIUSER MICROGRAVITY SCIENCE FACILITY FOR USE BY THE FLUID/DYNAMICS SCIENCE COMMUNITY ON BOARD THE SPACE STATION FREEDOM LABORATORY

CURRENT  
EFFCP<sup>TM</sup>

### DEFINITION-STUDY & CONCEPTUAL DESIGN

#### APPROACH:

- START WITH A REPRESENTATIVE LIST OF POTENTIAL MICROGRAVITY SCIENCE EXPERIMENTS FOR FLUIDS OVER A BROAD RANGE OF CONDITIONS/REQUIREMENTS
- WORK WITH REPRESENTATIVES OF EACH OF THESE POTENTIAL EXPERIMENTS TO DETERMINE REQUIREMENTS
- GENERATE PRELIMINARY CONCEPTUAL SCHEMATIC DIAGRAM FOR EACH POTENTIAL EXPERIMENT AS IT MIGHT EXIST IN THE USL ENVIRONMENT
- GENERATE A DATABASE OF EXPERIMENTAL REQUIREMENTS
- EXTRACT COMMON SYSTEMS TO FORM THE BASIS FOR A HOST FACILITY
- MERGE COMMON SYSTEMS REQUIREMENTS WITH KNOWN SPACE STATION REQUIREMENTS/CAPABILITIES TO FORM A HOST FACILITY

# FLUID PHYSICS/DYNAMICS FACILITY

## REFERENCE EXPERIMENT SETS

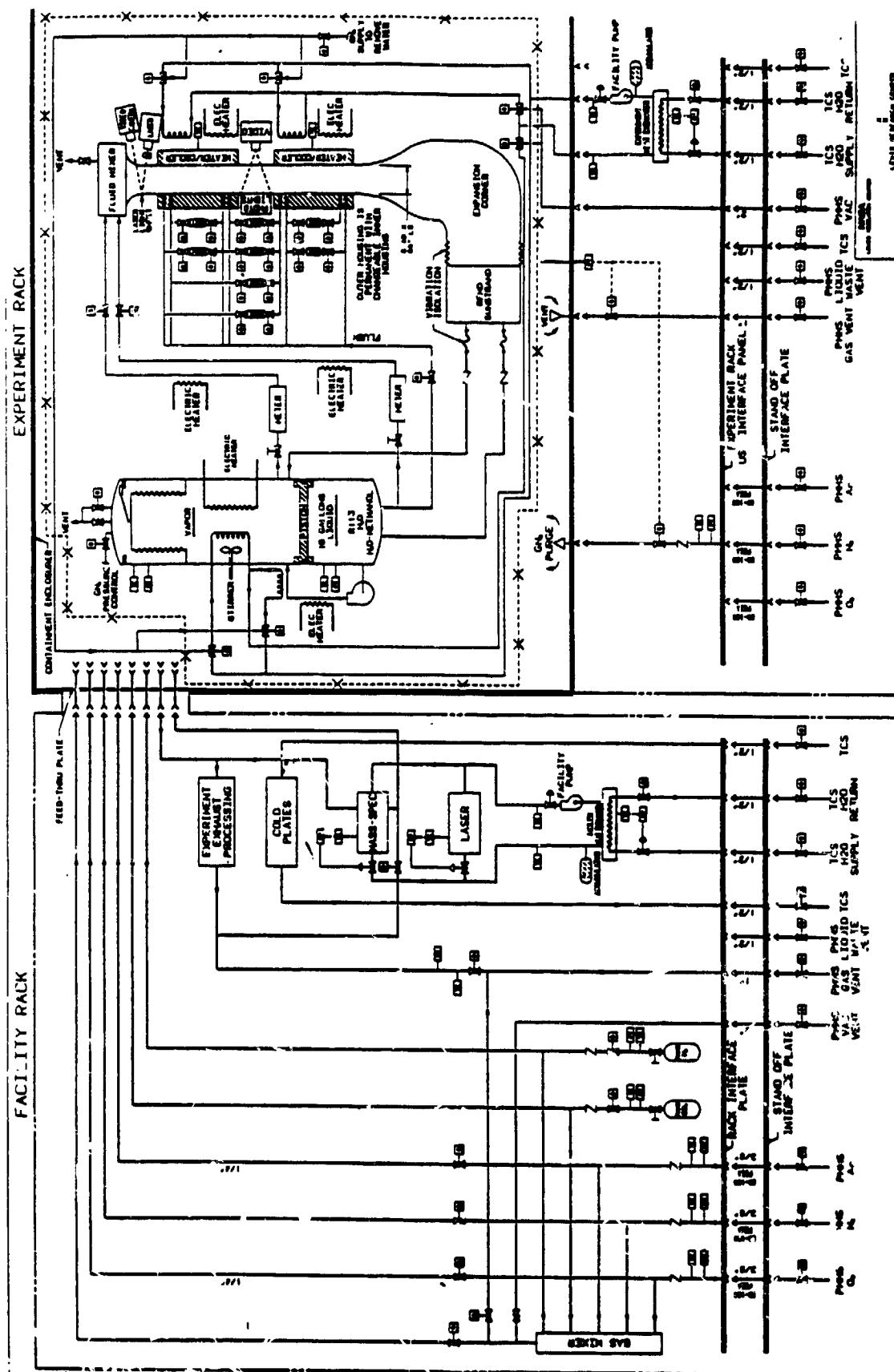
- [F01A] SURFACE TENSION INDUCED INSTABILITIES AND FLOW CHAI - L<sub>o</sub>R<sub>c</sub>
- [F01B] SURFACE TENSION DRIVEN CONVECTION PLINE - L<sub>o</sub>R<sub>c</sub>
- [F02] FREE SURFACE PHENOMENA CHAI - L<sub>o</sub>R<sub>c</sub>
- [F03] IMMERSED BUBBLE/DROPLET DYNAMICS AND INTERACTIONS BALA - L<sub>o</sub>R<sub>c</sub>
- [F04] THERMAL AND DOUBLE-DIFFUSIVE NATURAL CONVECTION KASSEMI - L<sub>o</sub>R<sub>c</sub>
- [F05] MULTIPHASE FLOW MCQUILLEN - L<sub>o</sub>R<sub>c</sub>
- [F06] FIRST ORDER PHASE TRANSITIONS CHIARAMONTE - L<sub>o</sub>R<sub>c</sub>
- [F14] CHEMICAL VAPOR DEPOSITION (CVD) CLARK - L<sub>o</sub>R<sub>c</sub>
- [F16] THERMAL GRADIENT EFFECTS ON ENTRY FLOW DEVELOPMENT CLARK - L<sub>o</sub>R<sub>c</sub>
- [F17] QUANIFICATION OF FLUID PHENOMENA THAT OCCUR DURING SOLIDIFICATION McCAY - UTSL/MSFC
- [F18] FLUIDS MIXTURES HEAT AND MASS TRANSFER GIARRATANO - NBS

REVISED 16 NOV 84



MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO



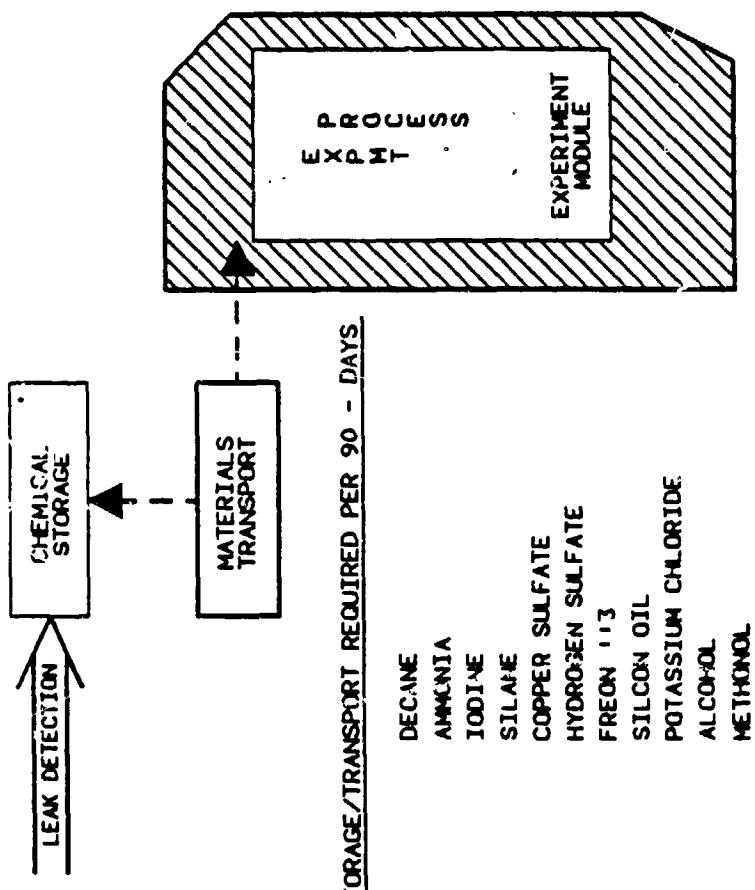
ORIGINAL PAGE IS  
OF POOR QUALITY

## FLUID PHYSICS/DYNAMICS FACILITY

### PRESENT FACILITY CONCEPTS

- NOW REVIEWING EXPERIMENTAL REQUIREMENTS  
AND JUST STARTING CONCEPT DESIGN
- MODULAR CONCEPT
- TWO RACK FACILITY
  - PERMANENT FACILITY RACK
  - INTERCHANGEABLE EXPERIMENT RACK
- FACILITY RACK
  - INTERFACE BETWEEN USL & EXPERIMENT
  - HOUSES SUPPORT SYSTEMS
  - POWER CONVERSION & DISTRIBUTION SYSTEM
  - DATA ACQUISITION & CONTROL COMPUTER SYSTEM
  - LASER DIAGNOSTIC SUPPORT SYSTEM
  - HIGH RESOLUTION HIGH FRAME RATE VIDEO SUPPORT SYSTEM
  - MASS SPECTROMETER
  - SAFETY SYSTEMS
  - OPERATOR INTERFACE PANEL
- EXPERIMENT RACK
  - RACK INTEGRATED ON GROUND
  - POSSIBLE CHANGE-OUT EVERY 12 TO 18 MONTHS
  - HOUSES CONTAINMENT ENCLOSURE
  - VARIOUS EXPERIMENT MODULES
    - MULTI-PHASE FLOW LOOP

FLUID PHYSICS/DYNAMICS FACILITY  
CHEMICAL STORAGE & MATERIALS TRANSPORTS USAGES

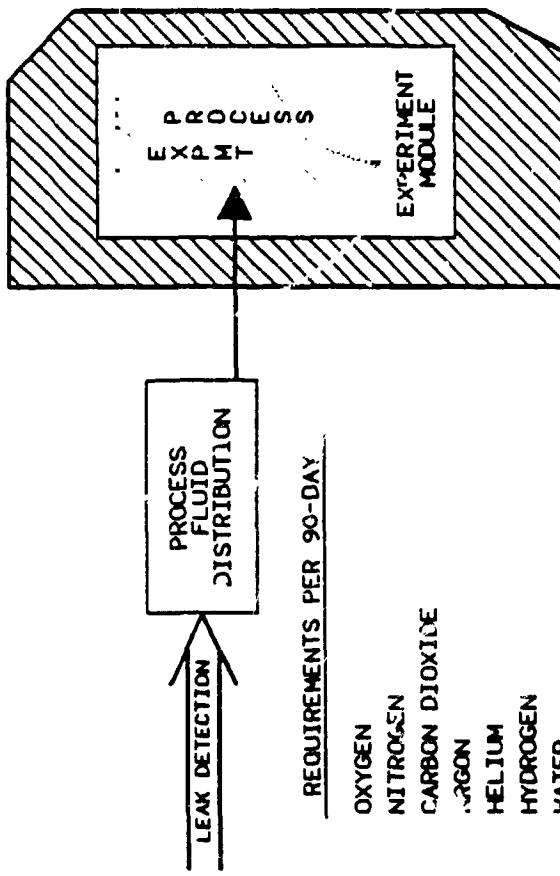


LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

**NASA**  
NATIONAL AERONAUTICS  
SP. SPACE ADMINISTRATION

FLUID PHYSICS/DYNAMICS FACILITY  
USL SUPPLIED CONSUMMABLES USAGE



- AMOUNTS WILL BE IN DATABASE

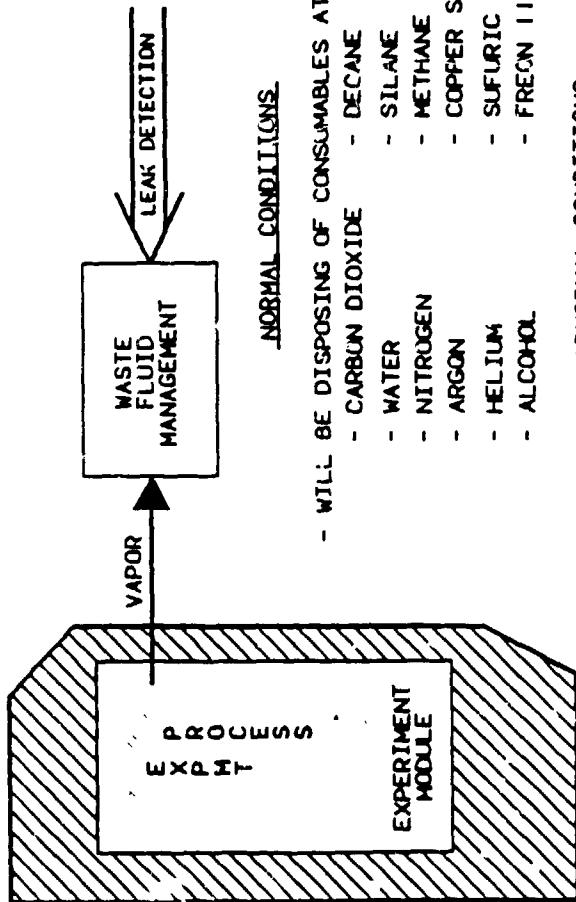
LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

## FLUID PHYSICS/DYNAMICS FACILITY

### WASTE FLUIDS MANAGEMENT USAGE



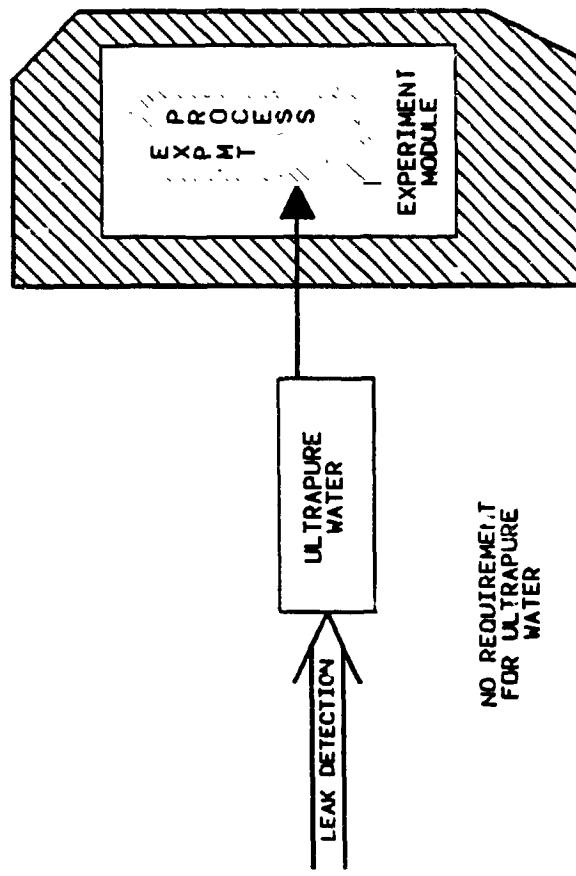
#### NORMAL CONDITIONS

- WILL BE DISPOSING OF CONSUMABLES AT END OF EACH RUN:
  - CARBON DIOXIDE
  - DECAN
  - WATER
  - SILANE
  - NITROGEN
  - METHANE
  - ARGON
  - COPPER SULFATE
  - HELIUM
  - SULFURIC ACID
  - ALCOHOL
  - FREON 113

#### ABNORMAL CONDITIONS

- IF A SEALED CELL WERE TO LEAK
  - AMMONIA CHLORIDE
  - IODINE
  - SILICON OIL
- AMOUNTS WILL BE IN DATABASE

FLUID PHYSICS/DYNAMICS FACILITY  
ULTRAPURE WATER USAGE



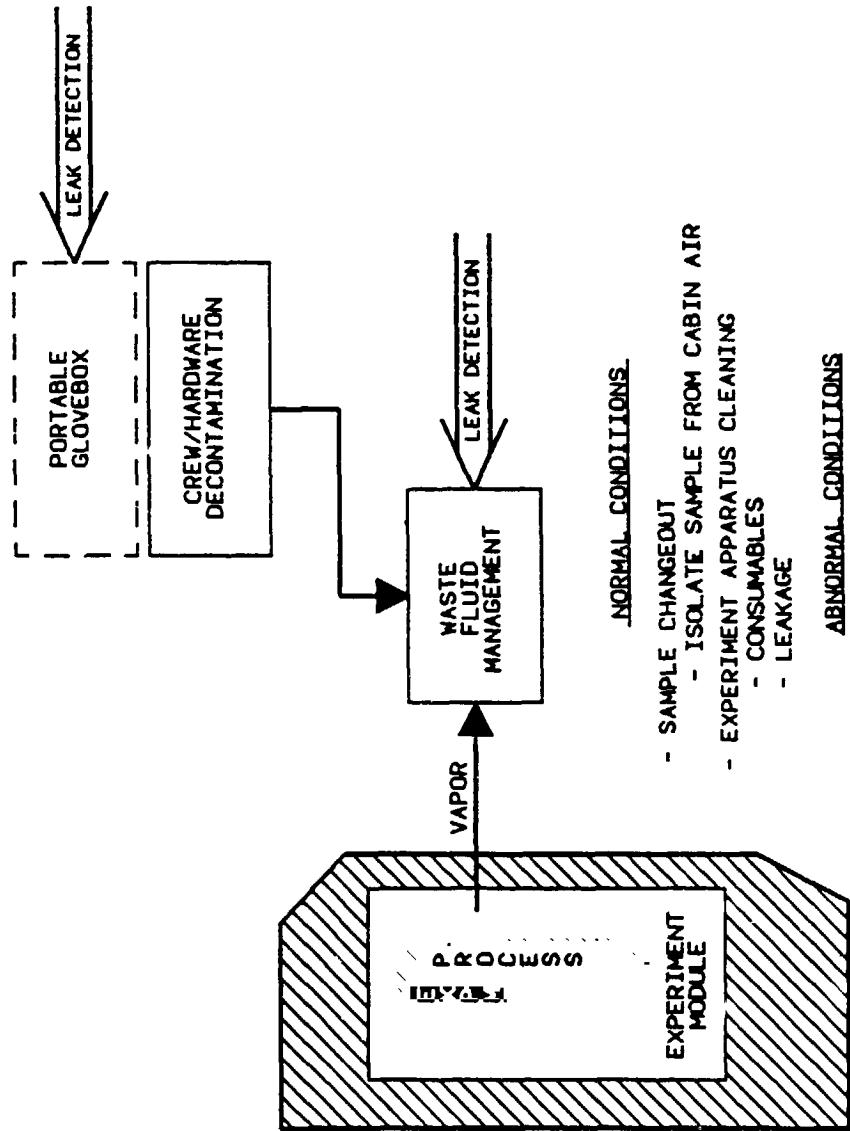
**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## FLUID PHYSICS/DYNAMICS FACILITY

### "PORTABLE GLOVEBOX USES"



#### NORMAL CONDITIONS

- SAMPLE CHANGEOUT
  - ISOLATE SAMPLE FROM CABIN AIR
  - EXPERIMENT APPARATUS CLEANING
  - CONSUMABLES
  - LEAKAGE

#### ABNORMAL CONDITIONS

- MAJOR CLEANUP
- POSSIBLE APPARATUS CHANGEOUT

**NASA**  
NATIONAL AERONAUTICS &  
SPACE ADMINISTRATION

MICROGRAVITY EXPERIMENT FACILITY STUDY TEAM

LEWIS RESEARCH CENTER  
CLEVELAND, OHIO

## FLUID PHYSICS/DYNAMICS FACILITY

### ISSUES AND CONCERNS

- MULTI-RACK FACILITY - INTER-RACK CONNECTIONS
- CONTAINMENT
- PMMS AVAILABILITY
- USL SUPPLIED FLUIDS
- EMERGENCY/CREW RESPONSE, ETC.
- PORTABLE GLOVEBOX
- USER INTERFACE WITH WP-01
- TECHNOLOGY DEVELOPMENT OF SYSTEMS
- COMPATIBILITY WITH JEM , COLUMBUS & CDSF

ADVANCED PROTEIN CRYSTAL GROWTH

Robert S. Snyder  
Space Science Laboratory  
Marshall Space Flight Center

ADVANCED PROTEIN CRYSTAL GROWTH FACILITY (APCGF)

**OBJECTIVES:**

*Grow large, high-quality crystals of proteins and other biological materials for use in studies of molecular structure*

*Analyze crystals in space by high resolution optical techniques and x-ray diffraction (as an optimum goal)*

*Investigate the kinetics of protein crystallization from solution by incorporating experiment diagnostics into the APCGF*

CHARACTERISTICS OF PROTEIN CRYSTALS

- o Small size 0.5 mm
- o 30 to 80% solvent
- o Few intermolecular contacts - mechanically unstable
- o Sensitive to temperature changes
- o Sensitive to pH changes
- o Sensitive to solvent loss or changes in solvent composition
- o Weak to moderate diffraction observed
- o Sensitive to x-rays
- o Finite lifetimes

## PCG DEVELOPMENT

Most protein crystals are grown by variations of the hanging drop method

Handheld PCG space apparatus essentially duplicates this laboratory's vapor diffusion apparatus

Deficiencies of experiment in space include:

Uncertain initial conditions of experiment

Unpredictable protein crystal growth operations and environment in space

Relatively short growth time

Delay in collecting and analyzing crystals

PRESENT PCG REQUIREMENTS

- o Load samples onboard within 24 hours of launch
- o Provide a method of carrying proteins and growth initiator separately, and observing deployment and mixing of each as required
- o Initiate crystallization as soon as possible after reaching orbit.
- o Maintain low gravity conditions to prevent droplet loss and optimum crystal growth conditions
- o Maintain constant temperature (40°C or 220°C)
- o Limit temperature excursions  $\pm 0.5$  degrees C
- o Provide manned access for operation and monitoring
- o Carry as many samples as possible (60 or more)
- o Retract sample into syringe as late as possible before re-entry
- o Remove from orbiter within approximately 2 hours after landing

FLIGHTS OF HANDHELD PCG EXPERIMENTS

0	STS 51-D	April 1985
0	STS 51-F	July 1985
0	STS 61-B	November 1985
0	STS 61-C	January 1986

FLIGHTS OF PCG EXPERIMENTS WITH GANGED DEPLOYMENT

0	STS-26	September 1988
0	STS-29	February 1989

TRANSITION FROM HANDHELD TO PRESENT GANGED MECHANISM

**New flight hardware incorporates:**

Initial stages of automation of experiment operation

Accommodation in constant temperature flight enclosures

Control of nucleation and growth based upon extensive laboratory research and testing

In-flight crystal growth analysis by photography

### PROTEIN CRYSTAL GROWTH EXPERIMENTS ON THE SPACE STATION

- o Requests for protein crystals grown in space exceed our capability to process them
- o Protein crystal growth is a dynamic flight program
  - Present flight experiments are flexible to stay ahead of the technology development on Earth
  - The dominant processes controlling protein crystallization are not known
  - Although hardware and operations are evolving as we gather information, basic facilities can be outlined
- o Space Station should provide the laboratory for preparing the protein solutions and analyzing the grown crystals by x-ray diffraction

EXPERIMENT PLAN FOR SPACE STATION

- 0 Protein samples will be prepared on orbit
  - o Most proteins will be carried to orbit as frozen pellets or lyophilized
  - o Mixing proteins with buffers, precipitants, etc., will be done at experiment initiation
- 0 Protein Crystal Growth facility will incorporate techniques such as:
  - o Vapor Diffusion
  - o Liquid-Liquid Diffusion
  - o Dialysis
  - o "Containerless"
  - o Epitaxy
- 0 Most isothermal experiments will be done at 4 degrees C and 22 degrees C; some experiments will require temperature gradients
- 0 Experiment duration will extend from several days to many weeks
- 0 Some analysis of the crystals will have to be done on orbit

UTILIZATION OF LABORATORY FACILITIES AND UTILITIES

APCGF will need:

- o Controlled temperature storage for the proteins (before the experiment) and grown crystals (before analysis and/or transport)
- o Glovebox for handling toxic proteins
- o High resolution video of critical crystallization steps
- o Facilities for analyzing crystals
- o Microscopy
- o X-ray Diffraction

### TOXIC AND REACTIVE MATERIALS

Many proteins of interest are toxic, e.g., scorpion toxin and sea anemone toxin flown on STS-51D

Quantities required for growing crystals are small (less than 1 milligram per 40 microliter drop)

Handling requirements will depend on facility and operations selected for the Space Station

### CONCLUSIONS

Protein Crystal Growth on the Space Station will involve handling of fluids, some containing toxic proteins

Robotic systems are available for multiple samples in the laboratory but goal of these systems is control over repetitive operations not limitation of toxic material handling

Telescience can be designed and developed to monitor and transfer proteins from solution to growth to analysis

System flexibility must be retained, however, as the APCG Science Working Group defines the goals, requirements and facility capabilities for the Space Station

**Biotechnology Facility  
and**

**Bioreactor Sterilization**

Presented at:

**Space Station Freedom  
Toxic and Reactive Materials Handling Workshop**

Nov. 1988

**William H. Bowie M.S.**

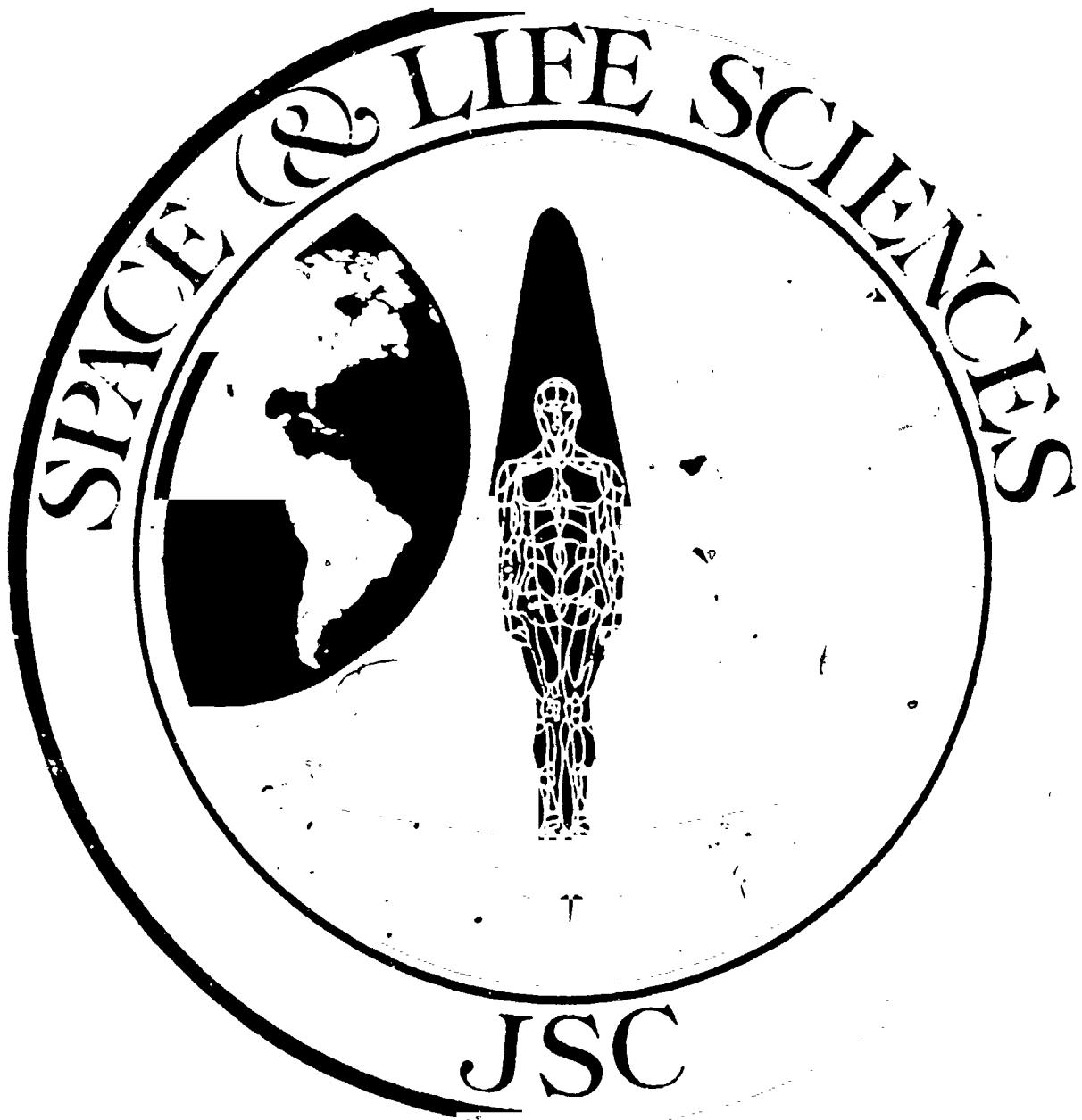
Krug International

(presenter)

and

**Steve R. Gonda Ph.D.**

NASA / JSC

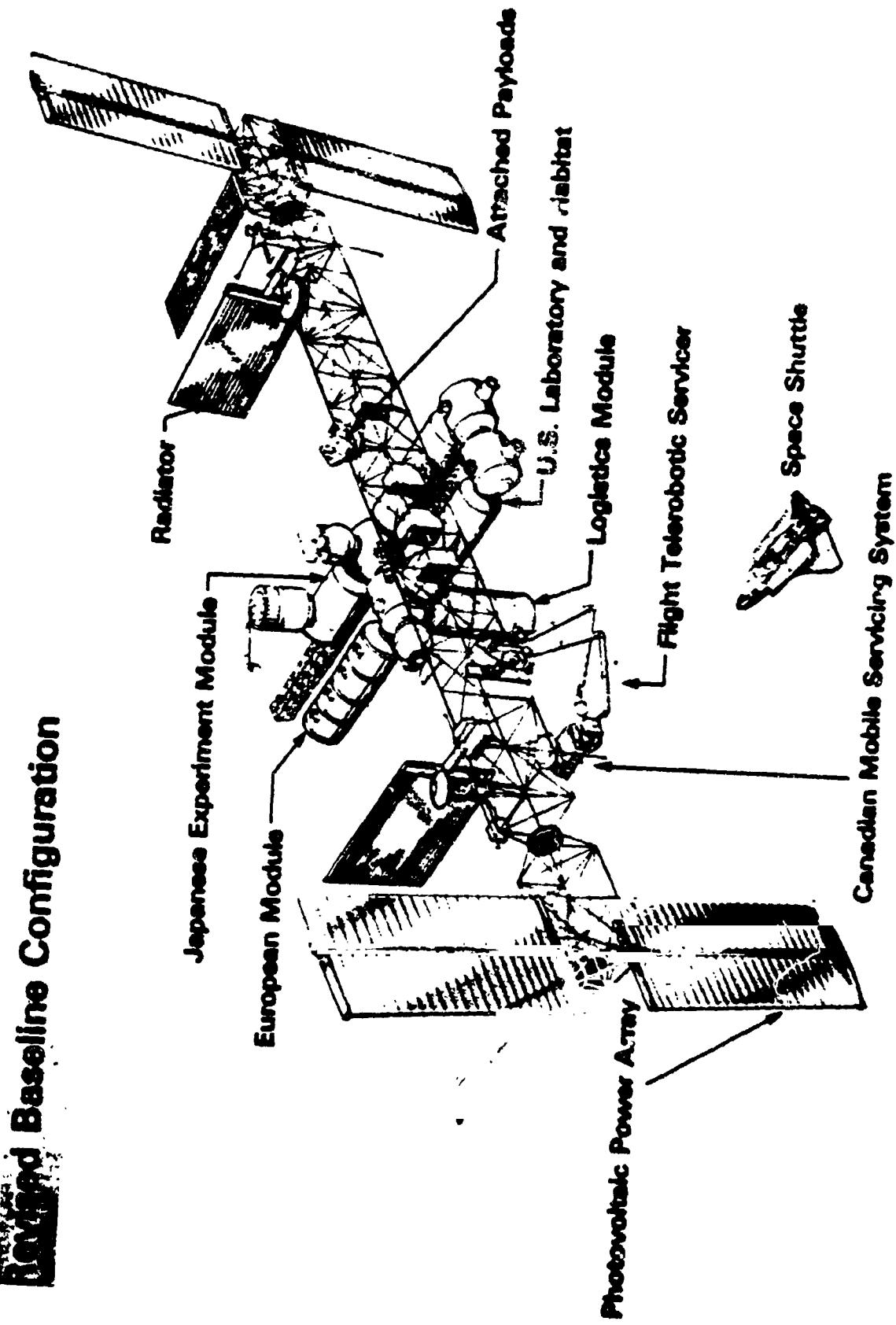


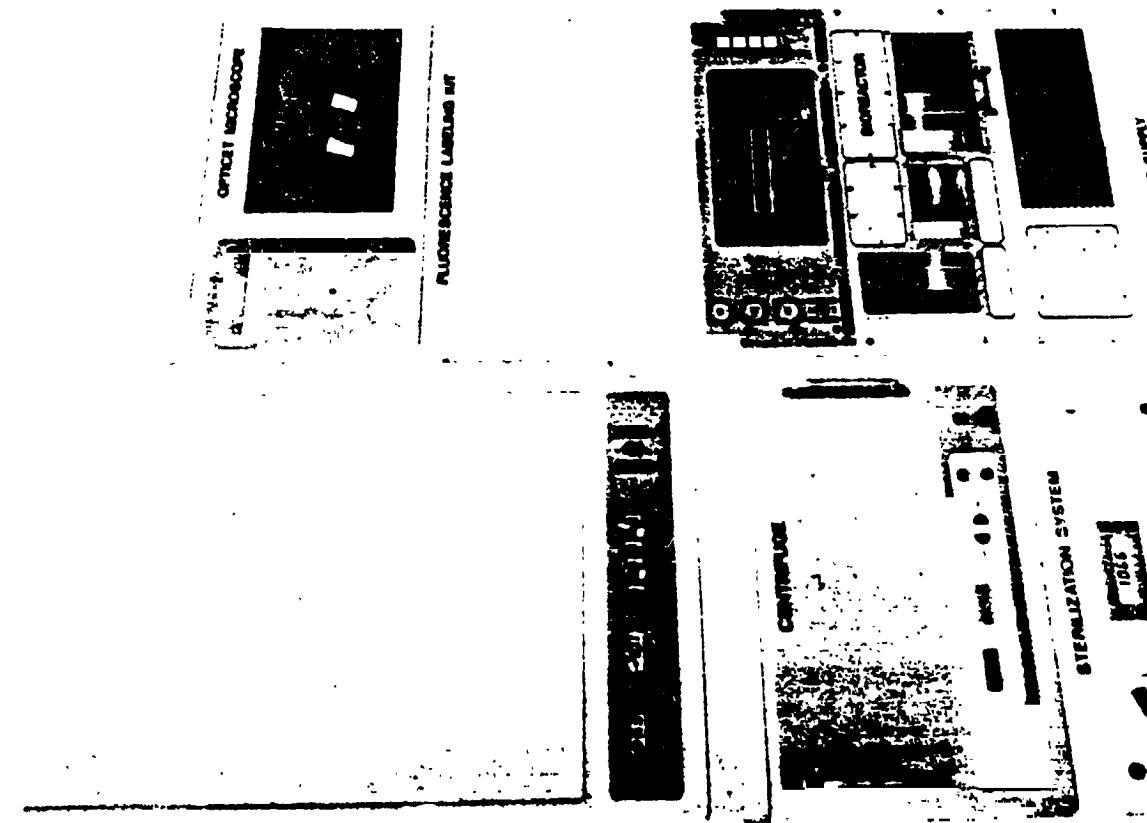
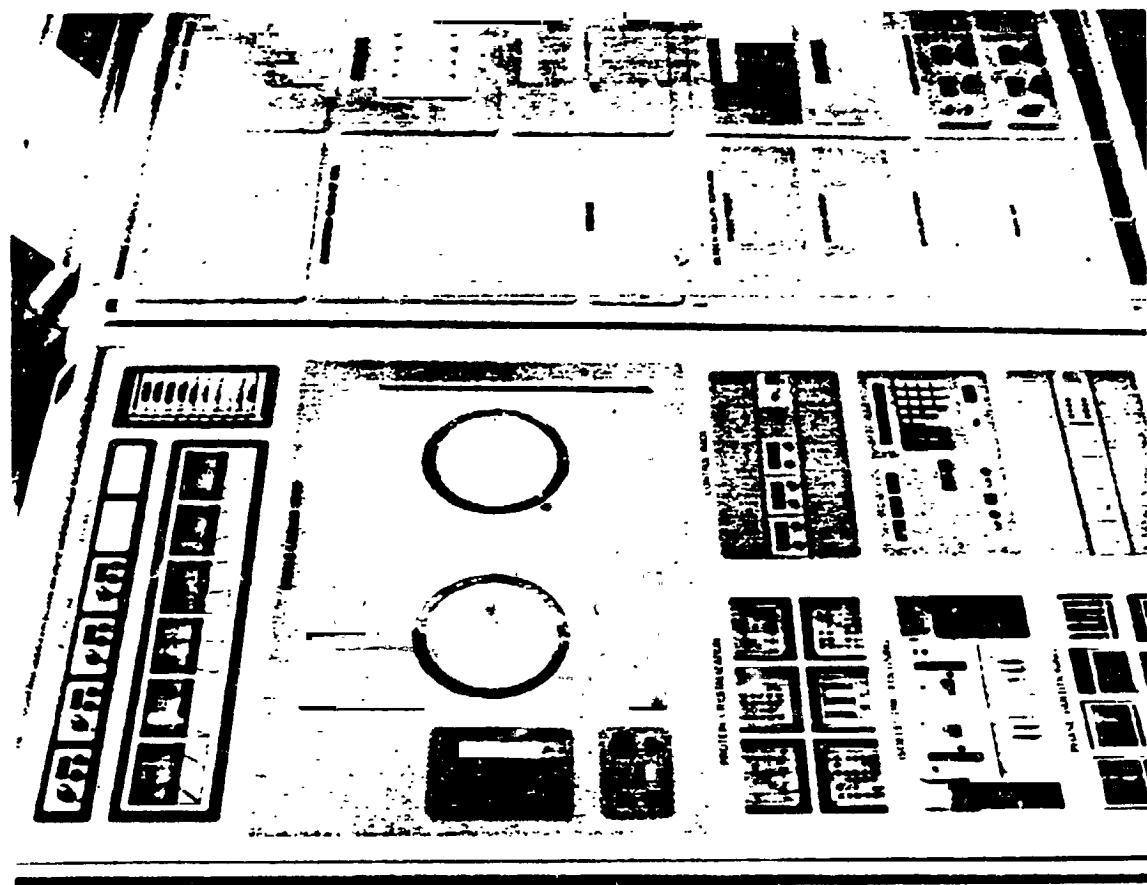
NASA

National Aeronautics and  
Space Administration

**Lyndon B. Johnson Space Center**  
Houston, Texas

## Baseline Configuration



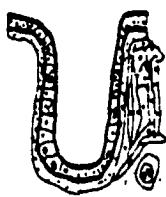


## BIOREACTOR USES

BIOREACTOR SYSTEM PROVIDES

### BIOLOGICALS

Cells and tissues



colon tissue showing  
crypt structure



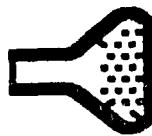
### AN APPARATUS IN WHICH TO STUDY THE EFFECTS OF

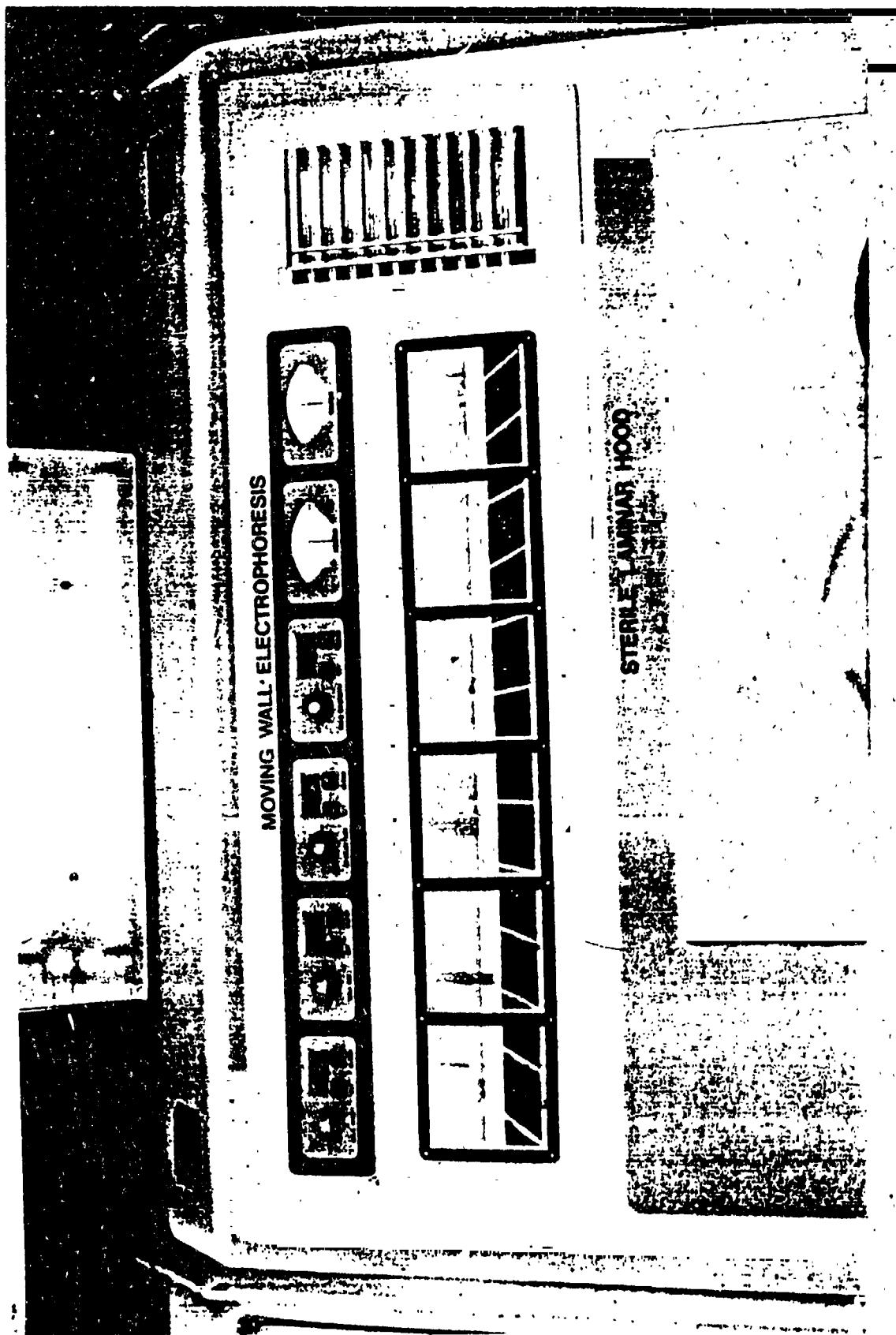
Shear, turbulence, and mixing



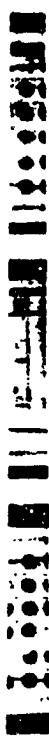
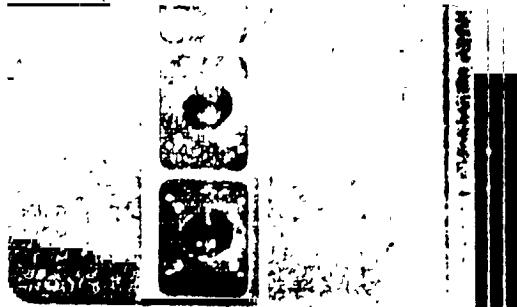
### RAW MATERIAL FOR PRODUCT EXTRACTION

Cell and Tissue secretory and excretory materials

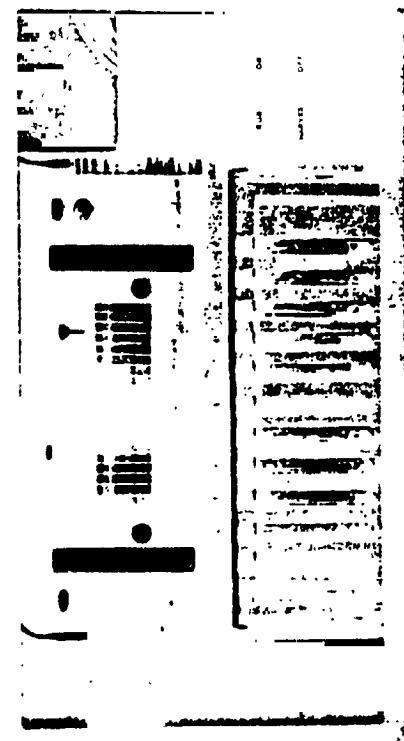




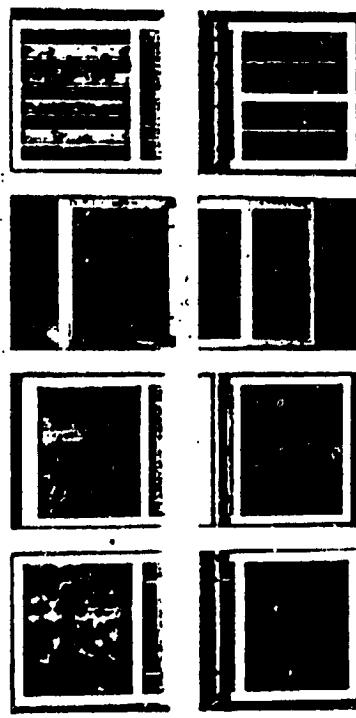
ORIGINAL PAGE IS  
OF POOR QUALITY



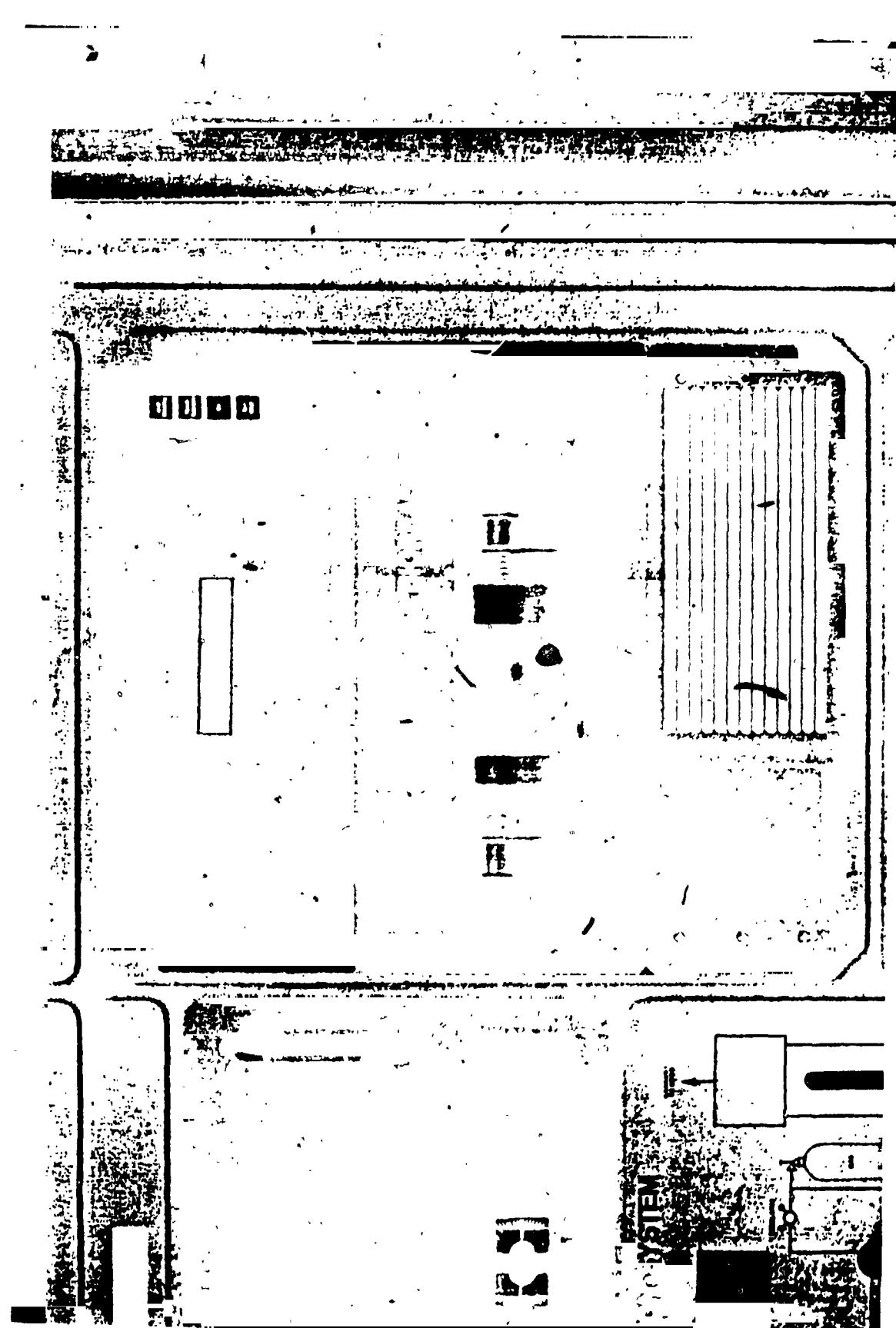
### ISOELECTRIC FOCUSING

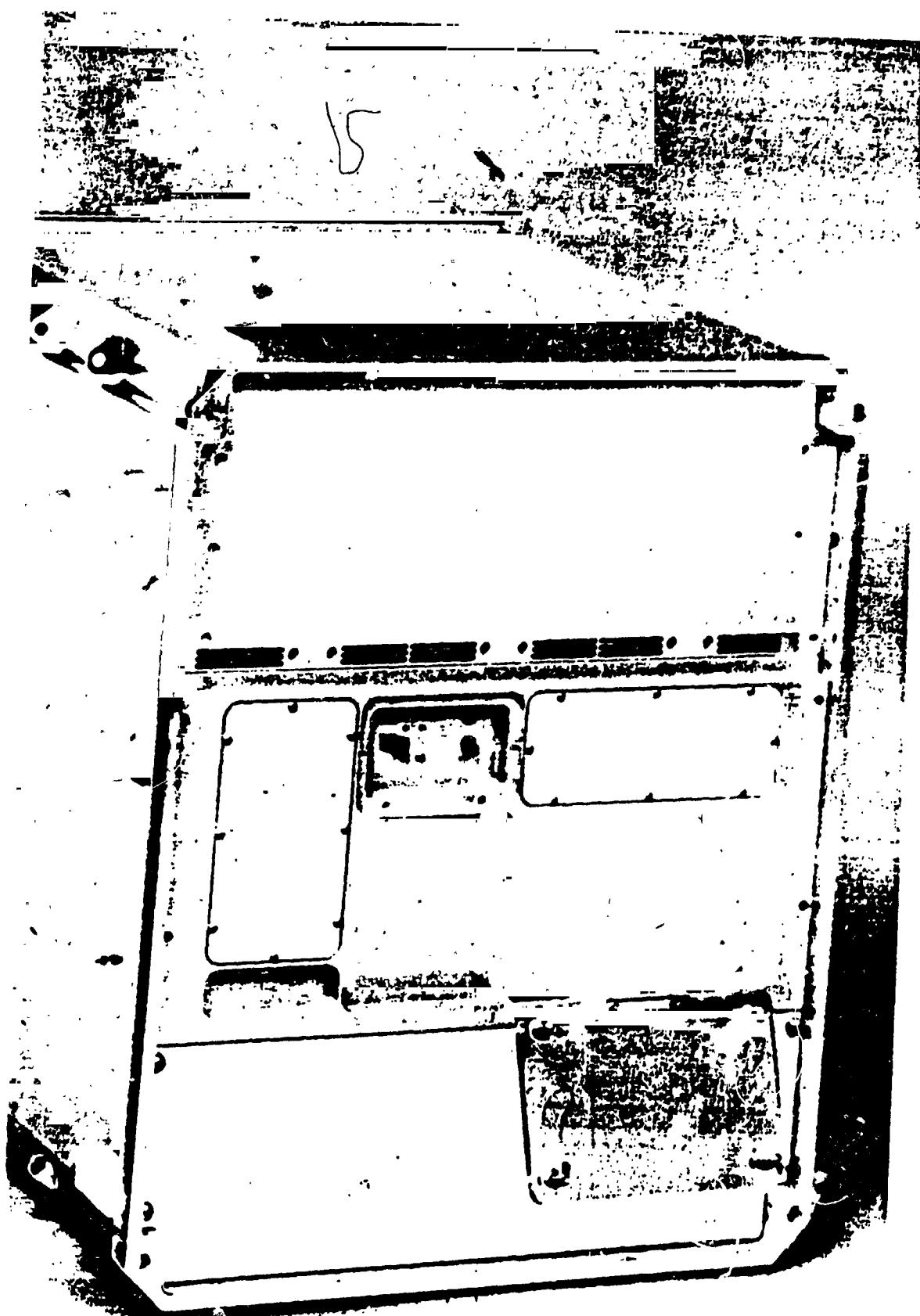


### PHASE PARTITIONING









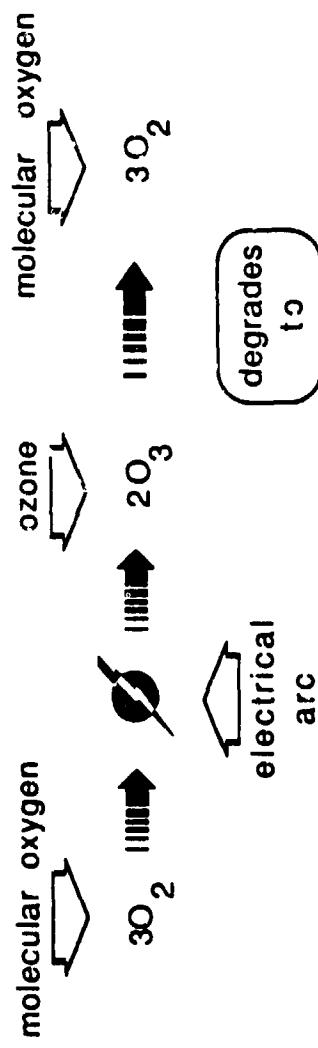
14-11

ORIGINAL PAGE IS  
OF POOR QUALITY

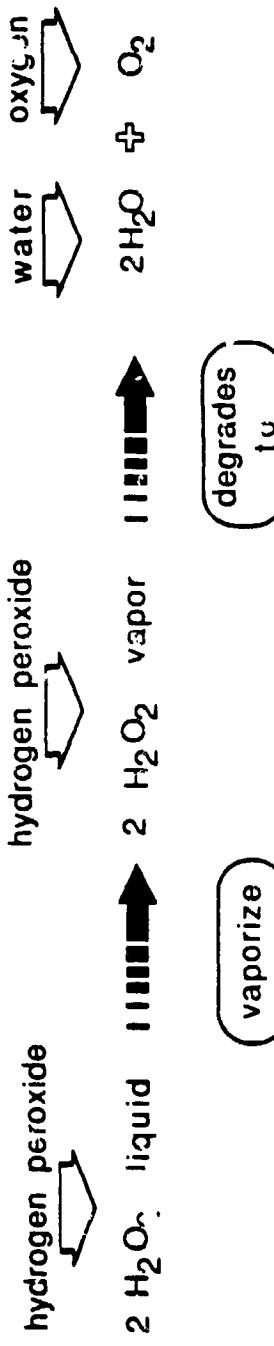
Circumstance	Compound	SIAC	Use	Hazard
Biorack FE VC	Sulfuric ether (Diethyl ether)	24.0		Irritant, CNS depressant
Specied D2	Diethanolamine	10.0	buffer component	Low level irritant and toxicity
	Dimethyl sulfoxide	200.0	carrier	Mild resp irritant
Refrigeration	Freon R-502	100.0 ppm	cooling	displace crowds from scrubber
Fixative VC	glutaraldehyde	0.2 - 0.4	tissue processing	irritant
	formaldehyde	0.1 - 0.12	tissue processing	irritant
Batteries	dimethyl sulfide	1.0	electrolyte	irritant
	arsenite	0.002		
	Tetrachloroate (ClO <sub>2</sub> )	0.083		irritant
	molecular iodine	0.1		irritant, pulmonary irritant
CR	Ag <sub>2</sub> CrO <sub>4</sub>	0.03		Corrosive
Sterilants, disinfectants	Acide A(ClO <sub>2</sub> ) (Cl <sub>2</sub> )	0.03 ppm 0.03 ppm	CFES	Toxic irritant
	Ethylene oxide	0.2 ppm	CFES	
	Glutaraldehyde		Fluorocar.	carcinogen
Acids	CR Acetic acid	7.4	tissue processing	irritant
	Phosphoric acid			
	Sodium Cacodylate (dimethyl arsenic acid, sodium salt)	0.18	tissue processing	
	Protonic		CFES	
Metals	arsenic	0.1	tissue processing	
Steins	methylene blue		RBC 11x stain	
	0.894	0.0004	tissue processing	irritant, stain, vegat.
Alcohols FE VC	Ethanol	94.0	tissue processing	
	Butanol	121.0	Phase partitioning	
Metabolic studies R	<sup>3</sup> H-uridine	100.0 Ci		
	<sup>14</sup> C-thymidine	100.0 Ci		carcinogen
	colchicine (colchicine)	0.5		carcinogen
Electrophoresis	Urea		CFES	Eye irritant
	diethanolamine	5.0	CFES	skin, eye irritant
Others	Sodium azide		preservative	irritant, lower BP, headache
	AgNO <sub>3</sub>	0.008		RBC fix stain
	potassium oxalate			RBC fix stain
	potassium cyanide			RBC fix stain

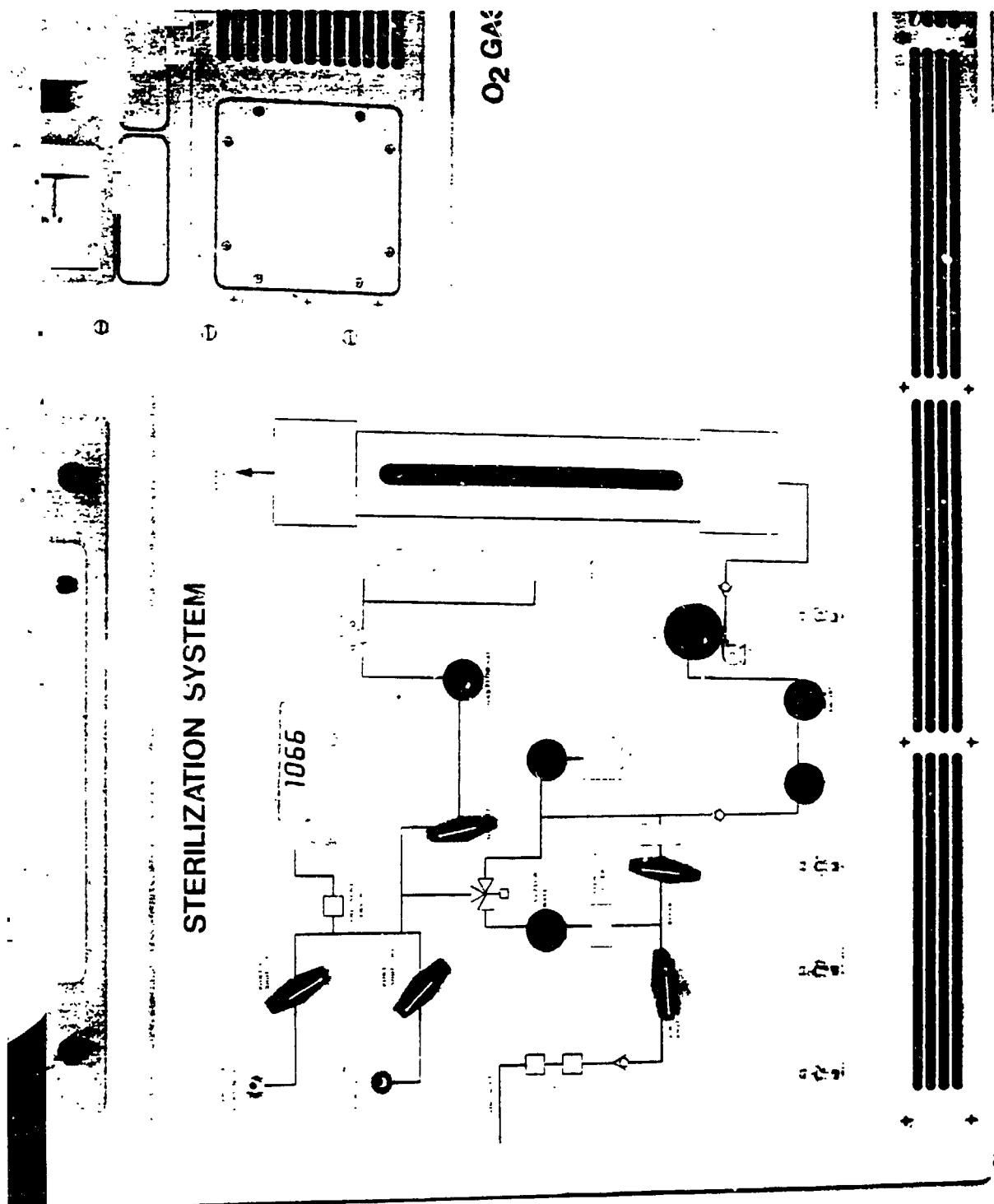
## OTHER STERILIZATION OPTIONS

### OZONE



### VAPOR PHASE HYDROGEN PEROXIDE





ORIGINAL PAGE IS  
OF POOR QUALITY

## Revised Baseline Configuration



TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

NON-HUMAN LIFE SCIENCE PAYLOADS

CONDUCTED IN THE

1.8 METER CENTRIFUGE FACILITY

CATHERINE C. JOHNSON  
BIOLOGICAL RESEARCH PROJECT OFFICE  
NASA/AMES RESEARCH CENTER  
MOFFET FIELD, CALIFORNIA  
NOVEMBER 29, 1988

## OUTLINE

- 1.8 M CENTRIFUGE FACILITY
- OPERATIONS
- INTERFACES
- ISSUES
- RECOMMENDATIONS
- SUMMARY

## 1.8 M CENTRIFUGE FACILITY

- 1.8 METER CENTRIFUGE
- ZERO-G HOLDING FACILITY
- LIFE SCIENCES GLOVEBOX
- SPECIMEN CHAMBER SERVICE UNIT (SCSU)
- MODULAR HABITATS FOR CENTRIFUGE  
AND HOLDING FACILITY
  - PLANTS
  - RODENTS
  - SMALL PRIMATES
  - GENERAL BIOLOGY

## SCIENCE DISCIPLINES

- CALCIUM HOMEOSTASIS
- CARDIOVASCULAR SYSTEM
- MUSCLE STRUCTURE AND FUNCTION
- ENDOCRINOLOGY/FLUID AND ELECTROLYTES
- HEMATOLOGY
- IMMUNOLOGY
- METABOLIC REGULATION
- NEUROSCIENCES
- PLANT PHYSIOLOGY
- RADIobiology
- REPRODUCTION AND DEVELOPMENT

## LIFE SCIENCES OPERATIONS

- ANIMAL TRANSFER BETWEEN FACILITIES
- SPECIMEN CHAMBER AND WASTE TRAY CHANGE OUT
- ANIMAL FOOD CHANGEOUT
- PLANT CHAMBER CLEANING
- PLANT NUTRIENT SOLUTION REPLENISHMENT
- SPECIMEN BLOOD DRAW
- URINE AND FECES COLLECTION
- ANIMAL INJECTIONS
- COMPLETE ANIMAL AND PLANT DISSECTIONS
- SNAP FREEZING OF TISSUE SAMPLES
- CHEMICAL FIXING OF TISSUE SAMPLES

## LIFE SCIENCES OPERATIONS (cont.)

- MASS MEASUREMENT OF TISSUE SAMPLES
- MASS MEASUREMENT OF PLANT AND ANIMAL SPECIMENS
- VISUAL OBSERVATION OF PLANT AND ANIMAL SPECIMENS
- ANIMAL ANESTHESIA
- MUSCLE BIOPSY
- SALIVA COLLECTION
- SPECIMEN LABELING
- MICROSCOPY
- SEED "PLANTING"
- PLANT MANIPULATION FROM GERMINATOR TO PLANT CHAMBER
- PLANT HARVEST

## REPRESENTATIVE RODENT SCENARIO

- PREPARE GLOVEBOX
- UNSTOW AND TRANSFER NECESSARY EQUIPMENT
  - SMALL MASS MEASUREMENT DEVICE
  - RODENT SUPPORT EQUIPMENT
  - SPECIMEN STORAGE SUPPLIES
  - SNAP FREEZER
- TRANSFER HABITAT TO GLOVEBOX AND REMOVE ANIMAL
- PERFORM OPERATIONS
  - WEIGH ANIMAL
  - DRAW BLOOD
  - SACRIFICE, DISSECT
- PRESERVE SAMPLES (FIXATIVE OR SNAP FREEZE)
- TRANSFER SAMPLES TO REFRIGERATOR, FREEZER, ETC.
- STOW EQUIPMENT
- SANITIZE/DECONTAMINATE GLOVEBOX
- BAG AND TRANSFER TRASH TO TRASH MANAGEMENT SYSTEM

## ANTICIPATED CHEMICALS

- FIXATIVES
  - FORMALDEHYDE
  - FORMALIN
  - GLUTARALDEHYDE
- CORROSIVES
  - HYDROCHLORIC ACID
  - SODIUM HYDROXIDE
  - ACETIC ACID
- OTHER
  - ETHANOL
  - EDTA
- DRUGS
  - ACEPROMAZINE
  - ATROPINE
  - KETAMINE HYDROCHLORIDE
  - OXYMORPHONE HYDROCHLORIDE
  - PENTAZOCINE (TALWIN)
  - PENTOBARBITAL SODIUM
  - XYLAZINE (ROMPUN)
  - RADIOISOTOPES
    - $^{3}\text{H}$ ,  $^{51}\text{Cr}$ ,  $^{59}\text{Fe}$ ,  $^{125}\text{I}$
- HOAGLAND'S SOLUTION

## S. S. FREEDOM SERVICES AND SUPPORT FUNCTIONS

- PMMS
  - TRASH MANAGEMENT
  - BIOSTABILIZED MATERIALS
  - RADIOACTIVE WASTES
- WATER REQUIREMENT
  - ELECTRONIC GRADE FOR PLANTS
  - HYGIENE QUALITY FOR SCSU
- WASTE WATER
  - CONDENSATE FROM HABITATS
  - BRINE FROM SCSU
- SPENT NUTRIENT FROM PLANTS
  - LN<sub>2</sub>
  - CO<sub>2</sub>, O<sub>2</sub>

## S.S. FREEDOM SERVICES AND SUPPORT FUNCTIONS (cont.)

- ECLSS
  - O<sub>2</sub> RESUPPLY AND CO<sub>2</sub> REMOVAL FOR ANIMALS
  - POTABLE WATER FOR ANIMALS
- LAB FACILITY EQUIPMENT
  - REFRIGERATOR
    - FREEZERS, -20° C, -70° C
  - LAB SUPPORT EQUIPMENT
    - CRYOFREEZER (SNAP AND STORAGE)
    - FREEZE DRIER
    - GAS CHROMATOGRAPH/MASS SPEC.
    - HIGH PERFORMANCE LIQUID CHROMATOGRAPH

## ISSUES

- INCREASED BIOBURDEN  
FROM CREW TO SPECIMEN
- TRACE CONTAMINENTS  
FROM CABIN TO SPECIMEN CHAMBER
- SPILLS/CLEANUP
- REPLACEMENT UNITS
- HUMIDITY RANGE

## RECOMMENDATIONS

- BUILD ON "LESSONS LEARNED" FROM SPACELAB
- CLOSE COORDINATION BETWEEN CFP AND PMMS DESIGNERS
- GOOD OPERATIONAL PROCEDURES
- CHEMICAL PACKAGING
- CONTINGENCY PLANNING

## SUMMARY

- 1.8 M CENTRIFUGE FACILITY PROVIDES BIOISOLATION
- ALL ANIMAL PROCEDURES IN GLOVEBOX
- ALL CHEMICALS HANDLED IN GLOVEBOX
- PMMS DESIGN CRITICAL TO CFP OPERATIONS